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January 27, 2020

SENT VIA EMAIL (toml@cityofgrassvalley.com)

Thomas Last
Community Development Director
City of Grass Valley
125 E. Main Street
Grass Valley, CA 95945

RE: Dorsey Marketplace Final Environmental Impact Report
SCH # 2016022053

Dear Mr. Last:

These comments on the Final Environmental Impact Report ("FEIR") for the Dorsey Marketplace project ("Project") are submitted on behalf of Protect CEQA and its members. Formed in 2014, Protect CEQA is a statewide coalition of environmentalists, labor members, and concerned residents committed to protecting the California Environmental Quality Act, open space preservation, and promoting smart growth development.

As we previously advised, "The new information and clarifications required to respond to the DEIR's flaws as identified in this comment letter will require recirculation of the DEIR for a new round of public comment." As described more fully below, the FEIR fails to confront the numerous environmental and human health impacts identified in our earlier letter in a transparent effort to simply avoid recirculation of the Draft EIR.

1. Human Health Implications from Automobile Air Emissions are Not Addressed

We previously explained, "Despite being located literally next to state route 20/49, the DEIR does not address this issue at all. The DEIR does not even mention state route 20/49 as an emission source for future Project occupants, much less quantify those TAC emissions or correlate those TAC emissions to actual health risks, if feasible, as required by *Sierra Club v. County of Fresno* (2018) 6 Cal.5th 502, 522 (*Sierra Club*)."

In response, the FEIR states, "[T]he traffic volumes on SR 20/49 do not warrant preparation of a health risk assessment . . . . As shown in Draft EIR Table 9-5, SR 20/49 in the project area carries approximately 29,350 vehicles." (FEIR, p. 2-292.) This statement is <u>false</u>; and the City knows it is false because on page 2-301 the FEIR states, "Table 9-5 states that the average daily traffic in 2016 was 29,350 when Caltrans identifies it as 41,000 . . . the comment is correct that the more approximate volume to use for this analysis is the volume given for State

Route 20, which shows 41,000." The City's misstatement of traffic volumes in order to avoid analyzing health impacts is untenable.[1]

Thus, 41,000 AADT is much closer to the 50,000 AADT "threshold" than 29,350 as the FEIR incorrectly reports. That said, 50,000 AADT is no longer a meaningful threshold that can be used, as the City attempts, to avoid analyzing the issue. As the City knows, the CARB Land Use Handbook ("Handbook") was prepared back in 2005; much more current and refined analyses are readily available such as BAAQMD's "CEQA GUIDELINES Risk and Hazard Screening Analysis Process Flow Chart," attached as Exhibit 1. Since the Northern Sierra Air Quality Management District ("NSAQMD") does not address this issue, the City has a duty under CEQA to inform itself about available methodologies for assessing an impact. (*Berkeley Keep Jets Over the Bay Comm. v. Board of Port Comm'rs* (2001) 91 Cal.App.4th 1344, 1367.) Under BAAQMD guidance, the City must perform at least a screening level assessment when proposing sensitive receptors within 500 feet of roadways with a minimum volume of 10,000 AADT. Exhibit 1. Here, the FEIR acknowledges that "the nearest residences would be approximately 170 feet from the travel lanes" (approximately 1/3 the buffer distance) from a freeway with a 41,000 AADT (more than four times the minimum roadway volume).

The City also attempts to justify its refusal to perform any analysis by citing certain mitigation measures such as vegetation or a sound wall that it generally claims might be able to reduce impacts. (FEIR, p. 2-292.) However, the FEIR provides no meaningful analysis of the effectiveness of such measures, nor does it identify these "strategies" as mitigation measures for an acknowledged potentially significant impact to human health. Finally, even if FEIR properly disclosed these "strategies" as mitigation measures and meaningfully discussed their effectiveness, the EIR would nonetheless remain defective without adequately analyzing the extent of the Project's impact on human health prior to mitigation. (*Sierra Club*, *supra*, 6 Cal.5th at 522, citing *Cleveland National Forest Foundation v. San Diego Assn. of Governments* (2017) 3 Cal.5th 497, 514.)

In short, the FEIR fails to adequately justify the City's refusal to ignore human health impacts to Project occupants resulting from Highway 20/49 TAC emissions that would be exacerbated by the Project.

Our prior letter also explained that DPM was not the only TAC requiring analysis, stating in relevant part, "Beyond diesel exhaust, UFPs are another air quality impact not discussed in the DEIR. UFPs, particles with diameters less than 0.1 micrometers, are comprised mostly of metals that are known constituents of brake pads and drums, as well as additive in motor oil. . . . The

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[1] This section only addresses automobile air emissions because the FEIR failed to even provide a response to prior comments on construction TAC emissions. (See FEIR, p. 2-294.) The FEIR merely added additional text to "restate" the DEIR's conclusions. Further, the FEIR response to comment does not address the BAAQMD guidelines included in the prior letter, which were included to illustrate an appropriate, updated approach to evaluating TAC emissions that would apply to any air district.

DEIR does not ever mention UFPs as a potentially significant air quality impact and therefore fails as an informational document."

In an attempt to dismiss this serious concern, the FEIR states, "[T]he comment recognizes that diesel engines are responsible for the majority of UFP associated with mobile emissions." (FEIR, p. 2-293.) This statement is false. The scientific study attached as Exhibit 2 to our prior comment letter explains, "Very fine and ultrafine iron, nickel, copper, and zinc were identified as vehicular, with the ***most probable sources being brake drums and pads and the lubrication oil additive zinc thiophosphate***." (Emphasis added.) The scientific study attached as Exhibit 6 to our earlier comment letter explains that "a major source [of UFP] is known to be ultra-fine metals from ***abrasion of brake pads and drums*** (Cahill et al., 2014)." (Emphasis added.) The FEIR provides no evidence that diesel engines are the primary source of UFP. In fact, the scientific literature plainly states that DPM and UFP are different airborne contaminants. The City's attempt to manufacture a demonstrably false reason to avoid addressing UFP emissions and resulting human health impacts is without merit.[2]

It is also noted that the City attempts to once again rely on knowingly false traffic volume data to excuse the DEIR's failure to address UFP emissions. Similarly, the City's attempt to rely on the Handbook is without merit since the Handbook, written in 2005, includes no discussion whatsoever of UFP emissions. The scientific community's understanding of the human health impacts from UFP emissions have developed following publication of the Handbook.

Finally, the City relies on CARB's *Technical Advisory Strategies to Reduce Air Pollution Exposure* ("CARB Technical Advisory") to claim, "[T]he distance between the proposed residences and the travel lane of the highway would ensure UFP concentrations near the residence would be substantially less than along the highway." (FEIR, p. 2-293.) It is telling that the FEIR does not cite any specific distances from the CARB report. FEIR acknowledges that the Project would locate residential units between 170 and 800 feet away from the travel lanes. (FEIR, p. 2-292.) The CARB Technical Advisory explains that UFP emissions travel much longer distances:

[2] Doubling down on its demonstrably false premise that heavy trucks are the source of UFP emissions, the FEIR attempts to distinguish the scientific study contained in Exhibit 1 to our prior comment letter by stating, "Exhibit 1 also discusses specific health concerns for students at Arden Middle School, noting that the school is downwind of roads that carry 65,000 vehicles per day, with 1.5% of those being heavy-trucks on Watt Avenue." It is difficult to understand how this is helps the City's position since it acknowledges that the percentage of trucks on Highway 20/49 is approximately 4 percent. Simple math reveals that 4 percent of 41,000 AADT is 1,640 trucks, which is more than 975 trucks (1.5% of 65,000). Thus, even if the City's false theory were correct, UFP emissions along this segment of Highway 20/40 would be greater than facing the Arden Middle School students in the Exhibit 1 study.

> In a study measuring near-roadway ultrafine particulate matter (UFP) size distributions and concentrations along the Interstate 405 freeway, Zhu et al. [25] found that UFP concentrations decreased with downwind distance from the freeway at night, but at a slower rate than is typically observed during the day. This finding sparked additional studies to characterize night-time and pre-sunrise pollution concentrations. These studies were motivated by concerns that near roadway pollution exposure had been previously underestimated and that ***many people living more than 300 meters (984 feet) from freeways were being adversely impacted by poor air quality*** at night and in the early morning. Like Zhu et al., these studies found both seasonal and diurnal differences in the rate of decline for pollution concentrations with increasing distance from pollution sources. Winer et al. [32] found that, before sunrise, UFP concentrations did not return to background levels until 2,600 meters (8,530 feet) from the freeway. Later in the morning and afternoon, pollutant concentrations exhibited the typical daytime downwind decrease to background levels within 300 meters (984 feet) downwind of the freeway.

(Exhibit 2 (CARB Technical Advisory), p. 13 (emphasis added).)

These increased transit distances for UFP emissions are consistent with the scientific studies cited in our earlier comment letter. Thus, while it is generally true that TAC and UFP emission concentrations drop off with distance, the distances contemplated in the scientific literature—including the technical cited in the FEIR itself—prove that this general rule offers no relief for the future occupants of the Project.

As we explained before, the City will need to prepare a recirculated DEIR that properly measures DPM and UFP emissions and the resulting human health impacts from these emissions. As explained in the recent *Sierra Club* decision, the DEIR will need to ***correlate*** those emission levels to identified health risks, if feasible. If not feasible, the recirculated DEIR will need to explain why so. The City's attempt to shirk its duty to analyze potentially significant human health impacts to future Project occupants (and thereby City residents), including an 86 percent increased risk of giving birth to an autistic child, violates the City duty of public disclosure under CEQA.

2. The EIR's Analysis of Biological Resources Remains Woefully Inadequate

The DEIR's analysis of biological resources, including the Biological Technical Report ("BTR") contained in Appendix E to the DEIR, was reviewed a consulting expert biologist, who noted that the site survey: 'was conducted at a time when special-status plants would not be evident and identifiable." (DEIR, p. 6-6) As a result, the City and the public can only speculate on the special-status plant species that may occur at the Project site." Rather than candidly admit this fatal defect and prepare proper analysis of biological resources, the EIR consultant simply revised the impact analysis methodology to reduce the biological impacts. Even worse, some of the revised analysis is based on an alleged new field study that was conspicuously never mentioned in the in the original BTR, and for which no supporting documentation has been provided in the FEIR.

Attached as Exhibit 3, and incorporate by this reference, are additional technical comments explaining how the FEIR and revised BTR have not adequately corrected the DEIR's multiple deficiencies in its analysis of biological resources.

3. The FEIR Has Not Corrected the Defective Analysis of Wastewater Treatment Impacts

The FEIR relies on the same improper arguments regarding the Project's cumulative impacts on public services, specifically wastewater treatment, failing to adequately address prior comments. (FEIR, pp. 2-299 to 2-301.) In fact, Response to Comment 22 simply rehashes the DEIR's conclusions and claiming the Wastewater Master Plan would solve the surcharges caused in part by the Project. Neither the DEIR nor the FEIR actually provide what authority requires the Project's developer to make a fair share payment to mitigate the Project's cumulative impacts to waste water infrastructure. The FEIR only makes a passing reference, stating that "payment of [the fair share] fee is required by City Policy" without actually providing a citation to which policy. (FEIR, p. 2-300.) Simply stating that the Project's developer would have to pay the fee is not an enforceable measure and is inadequate under CEQA.

Further, the insistence that the fair share payment is not mitigation for the Project is misplaced. The FEIR provides no authority supporting its novel position that application of citywide rules or fees is not somehow mitigation. No such authority exists. (See, e.g., *Anderson First Coalition v. City of Anderson* (2005) 130 Cal.App.4th 1173 (fair share fees can be effective mitigation, but only if "sufficiently tied to the actual mitigation"); Oakland Heritage Alliance v. City of Oakland (2011) 195 Cal.App.4th 884, 906 (compliance with existing regulations "is a common and reasonable mitigation measure").) Further, an EIR cannot incorporate proposed mitigation measures into its project description as a means to then conclude that potential impacts would be less than significant. (*Lotus v. Department of Transportation* (2014) 223 Cal.App.4th 645, 655-656.) Doing so prevents an accurate determination of a measure's effectiveness. (*Ibid*.)

The information in the FEIR also fails under rules for fair share payment mitigation established under *Anderson First Coalition v. City of Anderson* (2005) 130 Cal.App.4th 1173 (*Anderson First*). To establish the adequacy of a fair share mitigation measure, an EUR must include: (i) an identification of the required improvements; (ii) an estimate of the total cost of the required improvements; (iii) the project's individual contribution to the total improvement cost; and (iv) information establishing that the fees are part of a reasonable, enforceable plan or program sufficiently tied to the actual mitigation. (*Id*. at 1188-1189.) Neither the DEIR nor FEIR include this required information.

Contrary to Response to Comment 23, the FEIR has not "demonstrate[d] that the City has an adopted program to ensure adequate near-term and long-term sewage conveyance capacity and that the project would contribute a fair-share amount towards the City's implementation of the Wastewater Master Plan." (FEIR, 2-300.) Rather, the FEIR only alludes to a fair share payment scheme without providing the information necessary to prove its effectiveness as mitigation while conceding that the Project would have a potentially significant cumulative impact on wastewater infrastructure. The FEIR is inadequate for failing to adequately mitigate the Project's potentially significant impacts.

4. The EIR's Analysis of Noise Remains Defective

The FEIR states, "As stated on Draft EIR page 9-2, physical efforts to humans (discomfort or pain in the ear, hearing loss) typically begin to occur at noise levels of at least 120 dB." (FEIR, p. 2-303.) The FEIR mischaracterizes the DEIR's statement, as well as physical effect of loud noises on humans. The cited passage of the DEIR provides, "Sound levels above approximately 120 dB begin to be felt inside the human ear as discomfort and eventually pain at still higher levels." (DEIR, p. 9-2.) While it is true that sound levels at 120 dB cause these physical effects on humans, the DEIR does not assert that these are the first physical effects on humans at increasing noise levels. Indeed, the scientific literature confirms that much lower noise levels result in negative physical effects on humans. (See Exhibits 4, 5, 6, 7.) One of these studies explains:

> You can listen to sounds at 70 dBA or lower for as long as you want.
>
> Sounds at 85 dBA can lead to hearing loss if you listen to them for more than 8 hours at a time. Sounds over 85 dBa can damage your hearing faster. The safe listening time is cut in half for every 3-dB rise in noise levels over 85 dBA. For example, you can listen to sounds at 85 dBA for up to 8 hours. If the sound goes up to 88 dBA, it is safe to listen to those same sounds for 4 hours. And if the sound goes up to 91 dBA, your safe listening time is down to 2 hours.
> . . .
> Loud noise does not just hurt your hearing. It can cause other problems that you may not think of as being noise related.
>
> Noise can make you more tired and cranky. Loud noise can cause other health problems, like:
> high blood pressure
> faster heart rate
> upset stomach
> problems sleeping, even after the noise stops
> problems with how babies develop before birth

(Exhibit 5, Loud Noise Dangers, pp. 1, 4.)

The FEIR asserts, "The Draft EIR does not state or imply that exposure to more than 90 dB of noise results in human health impacts." (FEIR, 2-303.) If true, this is error and misleads the public. Readily-available scientific literature squares states that such human impacts exist, and will need to be addressed in a recirculated DEIR. (Exhibits 4, 5, 6, 7.) One report plainly states:

> "Mark Stephenson, a Cincinnati, Ohio–based senior research audiologist at the National Institute for Occupational Safety and Health (NIOSH), says his agency's definition of hazardous noise is sound that exceeds the time-weighted average of 85 dBA, meaning the average noise exposure measured over a typical eight-hour work day."

(Exhibit 6, p. A-36 (emphasis added).)

In an apparent attempt to refute the scientific literature, the FEIR states that the DEIR's Table 9-2 "lists example of noise levels for common noise sources" and somehow "demonstrates that limited exposure to sound levels of 90 dB does not cause significant adverse health impacts." (FEIR, 2-30.) Nonsense. The mere listing of "common noise sources" in a table for reference purposes in no way contradicts the scientific literature stating that noise levels above 85 dBA is hazardous to health.[3]

The City also states that the City's noise ordinance "is not the appropriate threshold of significance." (FEIR, p. 2-303.) Even if correct, the EIR nevertheless continues to violate CEQA because it simply never identifies a significance standard for construction noise.[4] The City's attempt to flout its noise ordinance is not correct, however, because neither the claimed "temporary" or "fluctuating" nature of construction noise justifies deviating from existing standards. The report attached as Exhibit 5 explains, "And if the sound goes up to 91 dBA, your safe listening time is down to 2 hours" – in a single eight-hour period. (Exh. 5, p. 1.) Thus, just one day of construction noise at 82 dBA (as predicted in the DEIR) can lead to hearing loss.

In sum, the FEIR has in no way adequately justified the DEIR's patently inadequate analysis of construction emissions.

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3 Table 9-2 merely identifies various sources of noise and their general decibel level for reference purposes. There is no language purporting to identify what noise level is safe or unsafe. Indeed, Table 9-2 also includes a noise level of 110 dB for a "rock band." Is the City suggesting that 110 dB is a safe noise level also? The FEIR's analysis is nonsensical.

4 "[A] threshold of significance cannot be applied in a way that would foreclose the consideration of other substantial evidence tending to show the environmental effect to which the threshold relates might be significant". (*Amador Waterways*, *supra*, 116 Cal.App.4th at p. 1109.)

5. The EIR's Analysis of Transportation Remains Inadequate

A. The EIR Fails to Adequately Analyze Impacts and Mitigation Related to LOS

The City has a legal duty to analyze level of service ("LOS") impacts under CEQA until June 30, 2020. The City's duty to analyze LOS impacts after June 30, 2020 in order to be able to demonstrate consistency with the General Plan. (2020 General Plan, p. 4-5 ("The City has established Level of Service 'D' as the goal for both the General Plan and for the development of Citywide and regional traffic impact fees.").) Our earlier letter explained that the DEIR's analysis of transportation impacts fails as an informational document. These same deficiencies prevent a finding that substantial evidence supports the City's determination that the Project is consistent with the General Plan's Level of Service goal.

Our prior letter noted that "the payment of a 'fair share' impact fee is not adequate mitigation when (as here) there is no evidence that the payment of the fee will actually result in mitigation of a project's significant environmental impacts." In response, the FEIR states, "Text has also been added to Impacts 8-2 and 8-9 regarding the costs for the CIP improvements to which the project must contribute. (FEIR, p. 2-290) This assertion is false. Although some additional discussion was added to the FEIR, none of the revised text provides the substantive cost, revenue and allocation information required by CEQA for the public to determine whether it is a "reasonable plan of actual mitigation." (*Anderson First Coalition v. City of Anderson* (2005) 130 Cal.App.4th 1173, 1187 (*Anderson First*). The FEIR's revision to Mitigation Measure 8a is a good example. The FEIR now states:

> Mitigation Measure 8a requires the project applicant to ~~contribute a fair-share payment towards the~~ construct~~ion of~~ the improved barrier at the Idaho Maryland Road and Brunswick Road Intersection and to contribute a fair-share payment towards signalization of this intersection, as included in the City of Grass Valley Traffic Impact Fee and CIP. Implementation of Mitigation Measure 8a would ensure that the Idaho Maryland Road and Brunswick Road intersection operates at an acceptable LOS under the cumulative plus project condition.

(FEIR, p. 8-31-32.)

Simply adding the clause "as included in the City of Grass Valley Traffic Impact Fee and CIP" does not provide the information required by *Anderson First* and its progeny for the public to determine whether the impact fee program relied upon is chronically underfunded and therefore not reasonably likely to result in actual construction of the required mitigation. (*Napa Citizens for Honest Government v. Napa County Board of Supervisors* (2001) 91 Cal.App.4th 342, 363–364 (*Napa Citizens*).) *Napa Citizens* is instructive because it expressly considered whether a fee program was adequately funded in order to constitute effective mitigation. (*Napa Citizens*, *supra*, 91 CalApp.4th at 363-364.) Indeed, the court in *Napa Citizens* found that the fee program was not effective mitigation because it could not raise sufficient revenue to cover the cost of the proposed infrastructure to mitigate the impact:

> Fee-based infrastructure can be an adequate mitigation measure under CEQA [citation omitted], and can be particularly useful where, as here, traffic congestion results from cumulative conditions, and not solely from the development of a single project. . .
>
> The cost of the highway improvements, however, is far greater than $2 million; indeed, the County estimates that the improvements will cost $70 million . . . . Although the existing mitigation fee appears to be a reasonable attempt to have developers pay their proportionate share of the cost of needed highway improvements, and the continued use of such fees undoubtedly would be useful, it cannot reasonably be argued that the funds that the County already has raised or that it reasonably can expect to raise in the future, will be enough to mitigate the effect on traffic that will result from cumulative conditions.

(*Ibid*.; see also Kostka & Zischke, Practice Under the California Environmental Quality Act (Cont.Ed.Bar. 2d ed. 2019) § 14.9, p. 14-13 ("Evidence showing that identified funding is not sufficient to support a mitigation plan, however, can provide a basis for challenging that plan").) Here, the City refuses to provide information necessary for the public to determine whether the fee programs relied upon by the City to mitigate the Project's impacts are, in fact, sufficiently funded in order to constitute a "reasonable plan of actual mitigation." (*Anderson First, supra,* 130 Cal.App.4th at 1187.)

Other informational deficiencies persist. Our prior comment letter noted the internally inconsistent analysis of impacts and mitigation for Intersection 12. Despite revising some relevant text, the significant informational deficiencies persist. For example, the FEIR states, "Alternative B would increase delay by 35.5 seconds (see Table 8-9). The City has identified replacement of the existing porkchop barrier at this location as the necessary improvement for the existing conditions." (FEIR, p. 2-289.) After acknowledging that the Project would increase delay by 35.5 seconds to an incredibly 157.6 total seconds of delay, the EIR never informs the public what the resulting delay would be with the "porkchop." CEQA does not allow a lead agency to simply label an impact "significant" and moving on without required analysis. But this is precisely what the City has done with respect to Intersection 12, and so the public is deprived of knowing whether the "porkchop" is effective mitigation and also whether different a different mitigation strategy might be more effective.

B. The EIR Does Not Analyze Impacts Using VMT

To the extent that the City suggests in the future that its failure to adequately analyze the Project's LOS impacts and mitigation is somehow not prejudicial, this effort will fail. Pursuant to Public Resources Code section 21099, subdivision (c) and CEQA Guidelines section 15064.3, vehicle miles travelled ("VMT") replaces level of service ("LOS") as the metric for determining the significance of transportation impacts under CEQA on July 1, 2020. Consistent with existing law, the DEIR and Appendix G only evaluate the Project's impacts on LOS, ignoring VMT as the appropriate standard. (See DEIR, pp. 8-11 to 8-24; see also Appen. G.) In fact, VMT is only mentioned in relation to Impact 16-1, whether the Project would cause temporary increases in wasteful energy consumption, and Impact 16-2, whether the Project would cause a permanent increase in wasteful energy consumption. (See DEIR, pp. 16-10 to 16-14.) Thus, the City was aware of the Project's impacts to VMT, yet failed to evaluate those impacts in the context of transportation impacts.

Since the EIR has not identified a significance standard for VMT, it is impossible to determine whether the annual 17,584,086 VMT generated by the Project is significant or not. The CEQA Guidelines provide some insight, however, by noting, "Projects that decrease vehicle miles traveled in the project area compared to existing conditions should be premised to have a less than significant transportation impacts." (CEQA Guidelines, § 15064.3, subd. (b)(1).) In light of this, it is difficult to see how an increase of more than 17 <u>million</u> vehicle miles travelled could be considered a less than significant impact.

In short, the EIR fails as an informational document whether considering LOS or VMT as the appropriate measure of a significant impact. As explained previously, the City will need to prepare and recirculate a revised DEIR that properly analyzes the Project's transportation impacts.

6. <u>Water Supply Is Uncertain</u>

In its comments on the DEIR, the Nevada Irrigation District ("NID") notably stated that it "anticipates a shortfall in water supply during a dry year scenario by the year 2035" and contradicted the DEIR's conclusion that NID has sufficient water supply to meet future demands. (FEIR, pp. 2-43 to 2-44.) While the City may have corrected the information in the FEIR, that is not enough. A lead agency must demonstrate that future water supplies are reasonably likely to be available. (*Vineyard Area Citizens for Responsible Growth, Inc. v. City of Rancho Cordova* (2007) 40 Cal.4th 412, 432 (*Vineyard*).) Factual inconsistencies or lack of clarity regarding water supply leave the lead agency without substantial evidence to conclude that sufficient water is likely to be available for a project at full build-out. (*Id*. at 439.) The new information in the FEIR, that by 2035 NID will have a 469 acre-feet shortfall, and a 6,910 shortfall by 2040, in single dry years and multiple dry 4th years calls into question the reasonable likelihood of NID water supply availability for the Project. Simply citing to contingency planning, without actually describing such measures, is not adequate to overcome the plain deficiency in water supply for the Project.

7. <u>The EIR Fails to Adequately Analyze Urban Decay</u>

Under CEQA, a lead agency must address the issue of urban decay in an EIR when a fair argument can be made that the proposed project will adversely affect the physical environment. (*Cal. Clean Energy Comm. v. City of Woodland* (2014) 225 Cal. App. 4th 173; CEQA

Guidelines, § 15131, subd. (a).) The seminal case of *Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 1207, explains:

> [W]hen there is evidence suggesting that the economic and social effects caused by the proposed shopping center ultimately could result in urban decay or deterioration, then the lead agency is obligated to assess this indirect impact. Many factors are relevant, including the size of the project, the type of retailers and their market areas and the proximity of other retail shopping opportunities. The lead agency cannot divest itself of its analytical and informational obligations by summarily dismissing the possibility of urban decay or deterioration as a 'social or economic effect' of the project.

Here, the Project proposes more than 100,000 square feet of new retail space, including two new massive retail anchors of up to 35,000 square feet each. This large amount of proposed new retail space supports a fair argument of significant economic impacts, and so the EIR correctly purported to analyze urban decay. (DEIR, p. 5-14, Appendix D.) However, the EIR's actual analysis does not represent a good faith effort at full disclosure of urban decay for several reasons.

First, the EIR makes no attempt to quantify the amount by which the Project would reduce existing revenue in the downtown area. The DEIR's technical study acknowledges that downtown Grass Valley's total revenue is only $47.7 million, which is less than the $53 million predicted for the Project. Put simply, will the Project reduce downtown revenues by $10 million, $5 million or $1 million? This is never stated. Instead, the EIR's analysis appears premised on the nonsensical position that 100 percent of the Project's revenue would come from recapturing existing leakage out of the area, and so the economic impact on downtown revenue would be $0. (DEIR, Appendix D, p. 24 ("Dorsey Marketplace sales of $53 million represent about 35 percent of existing retail leakage.").) The DEIR's technical study attempts to side-step disclosing the economic impact on the downtown by stating, "Sales activity Downtown is more influenced by general economic conditions and factors affecting visitor travel and discretionary spending on entertainment and recreation. Development of Dorsey Marketplace would not change the reasons for shopping and dining Downtown." (DEIR, Appendix D, p. 24.) This statement may be correct, but it does not disclose the Project's economic impact on the downtown area. Does this sentence mean that there will be <u>no impact on the downtown at all</u>? If so, the EIR should more plainly state that conclusion and support it with analysis. If there will be any economic impact, then the EIR must analyze and disclose that economic impact in order to determine whether business closures, vacancies and resulting urban decay may result from that economic impact. (CEQA Guidelines, § 15064, subd. (e).)

Second, the EIR has made no attempt to analyze the existing physical conditions in the downtown area that may contribute to urban decay impacts. Are there existing vacancies? If so, are the vacancies of anchor spaces or grouped in a specific area? Have any existing vacancies been long term? These are important questions that remain unaddressed, but are necessary for a meaningful analysis of urban decay. (*Gilroy Citizens for Responsible Planning v. City of Gilroy*

(2006) 140 Cal.App.4th 911, 932-33; *Bakersfield Citizens, supra*, 124 Cal.App.4th at p. 1212; *American Canyon Community United for Responsible Growth v. City of American Canyon* (2006) 145 Cal. App. 4th 1062, 1082; *Anderson First, supra*, 130 Cal. App. 4th 1173, 1185.

Third, the EIR acknowledges that there are cumulative retail projects that could also contribute to economic impacts (DEIR, Appendix D, p. 23), but makes no effort to consider whether the cumulative impact may be significant or whether the Project may have a significant incremental contribution to that cumulative impact. (CEQA Guidelines, § 15130, subd. (a).)

The EIR will need to be revised to address these important issues in order to satisfy CEQA's public disclosure mandate on the issue of urban decay.

* * *

As demonstrated above, the FEIR has not corrected the fatal defects in the DEIR. The DEIR requires significant revision and recirculation in order to comply with CEQA's informational disclosure mandates before the Project may be approved.

Very truly yours,

SOLURI MESERVE
A Law Corporation

By:
Patrick M. Soluri

PS/mre

cc: Kristi Bashor, City Clerk, City of Grass Valley (kristib@cityofgrassvalley.com)

Attachments:

Exhibit 1	BAAQMD CEQA GUIDELINES Risk and Hazard Screening Analysis Process Flow Chart
Exhibit 2	2017 CARB Technical Advisory, Strategies to Reduce Air Pollution Exposure Near High-Volume Roadways
Exhibit 3	Technical comments regarding Biological Resources and Attachments A through E
Exhibit 4	Noise Levels Associated with Urban Land Use
Exhibit 5	Loud Noise Dangers
Exhibit 6	Decibel Hell
Exhibit 7	Children and Noise

EXHIBIT 1

BAAQMD CEQA GUIDELINES
Risk and Hazard Screening Analysis Process Flow Chart

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

The District's CEQA community risk and hazards screening tools are provided for lead agencies to consider in deciding whether there should be further environmental review of a project. Lead agencies may use the screening tools to assess a project's potential risk and hazard impacts, compare the results to the lead agency's applicable thresholds of significance, and determine whether additional analysis is necessary. The screening tools provide conservative estimates and are not based on actual Health Risk Screening Assessments. A refined analysis, including modeling, should be conducted for more accurate, and most likely lower, risk and hazard estimates. The screening tools are not intended to discourage infill development or affordable housing. The screening tools will continue to be updated to reflect the best available data. Contact the District for additional guidance on the tools and for conducting a more refined screening analysis.

This flow chart outlines the District's recommended screening analysis process. The screening tools provide estimates for $PM_{2.5}$ concentrations, cancer risk, chronic hazard risk, and acute hazard risk. For additional guidance on any of the steps refer to the Recommended Methods for Screening and Modeling Local Risk and Hazards (Modeling Report) (http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx) or contact District staff.

The following tools will be needed for the screening analysis:

- Google Earth, a free program – http://www.google.com/earth/index.html
- Stationary Source Screening Analysis Tool – County specific Google Earth (KML) files that map all the stationary sources permitted by the District with risk and hazard estimates (tool does not estimate acute hazards since the levels were found to be extremely low), http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx
- Highway Screening Analysis Tool – County specific Google Earth (KMZ) files that map all the highway links in the region with risk and hazard modeling estimates by distance, http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx
- Roadway Screening Analysis Tables – County specific tables containing estimates of risk and hazard impacts from roadways by AADT and distance (tables do not estimate acute or chronic hazards since the screening levels were found to be extremely low), http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx
- Local road traffic count data from the California Environmental Health Tracking Program – http://www.ehib.org/traffic_tool.jsp

Please note that risk reduction strategies may be considered and implemented at each step of the screening process. Risk reduction strategies include, but are not limited to:

- ✓ Setback/site design to reduce potential impacts to sensitive receptors through the use of commercial development, parking lots, landscaping, open space, or other uses that minimize exposure to sensitive receptors.
- ✓ Phase project to be built when the forecasted model year for roadways generates reduced impacts.
- ✓ Confirm that dry cleaners will be phasing out perc by project build out date.
- ✓ Install emission controls on back-up generators.

Contact District staff for additional risk reduction strategies as needed.

District staff will continue to update and expand screening tables and technical support tools. To report any errors or corrections in the District's tools, please contact District staff.

Contact info: Alison Kirk, 415-749-5169, akirk@baaqmd.gov.

BAAQMD Risk and Hazard Screening Analysis Process Flow Chart:

1. Identify emission sources within 1,000 feet of project's fence line.

Permitted Sources:

- Install Google Earth and download the county-specific Google Earth kml permitted source files from the District's website. The kml files map the stationary sources permitted by the District and provide conservative screening values for $PM_{2.5}$, cancer risk and chronic hazard index.
- Input the project's address into the Google Earth search bar. Use the ruler function to identify permitted sources within an appropriate radius of the project area.

Highways:

- Download the county-specific Google Earth kmz highway files from the District's website and identify the highway links near the project. The kmz files are available for 6 or 20 feet elevations to reflect whether people are located on the 1st floor or higher in a project.

Major Roadways:

- Identify the major roadways with at least 10,000 average annual daily traffic (AADT) near the project. AADT data is available from local transportation agencies; or from the California Environmental Health Tracking Program, http://www.ehib.org/traffic_tool.jsp

Are there any sources near the project? Yes → step 2. No → Project can assume no significant impact for risk and hazards. No further analysis needed.

2. Conduct initial conservative screening .

Permitted Sources:

- Click on the points in Google Earth to see estimated $PM_{2.5}$, cancer risk , and hazard values for the identified permitted sources.

Highways:

- Click on the Google Earth highway links to see estimated $PM_{2.5}$, cancer risk, and hazard values based on the highway's distance from the project and east/west or north/south direction from the project.

Major Roadways:

- Download the county-specific Roadway Screening Analysis Tables from the District's website. Look-up $PM_{2.5}$ and cancer risk values based on the roadway's AADT, distance from the project, and east/west or north/south direction from the project.

Determine Impacts:

- Compare each source's estimated risk, $PM_{2.5}$, and hazard to the applicable thresholds as determined by the lead agency. Sum all the sources' impacts for comparison to applicable cumulative thresholds.

Are the risk and hazard estimates below the lead agency's thresholds of significance? No → step 3. Yes → Project can assume no significant impact for risk and hazards. No further analysis needed.

3. Conduct advanced screening for more refined estimates.

Permitted Sources:

- District staff can provide tips for scaling concentrations based on distance.

Highways and Major Roadways:

- Highway and roadways risk and $PM_{2.5}$ values can be scaled to reflect actual AADT and distances from the project.
- To modify the values based on AADT, divide the actual AADT by the AADT in the screening table. Multiply that value with the risk in the screening table: (Actual AADT/Screening AADT) x Screening Value = Actual AADT Value. See Section 3.1.2 in the Modeling Report for additional guidance.
- To refine estimates based on the exact distance of the roadway to the project see Section 3.1.2 in the Modeling Report.

Determine Impacts:

- Compare each source's estimated risk, hazard, and $PM_{2.5}$ to the applicable thresholds as determined by the lead agency. Sum all the sources' impacts for comparison to applicable cumulative thresholds.

Are the risk and hazard estimates below the lead agency's thresholds of significance? No → step 4. Yes → Project can assume no significant impact for risk and hazards. No further analysis needed.

4. Conduct refined modeling analysis.

Permitted Sources:

- If the results of the refined screening exceed any thresholds, the user may opt to conduct site-specific air modeling analysis. See Section 4.0 in the Modeling Report for additional guidance.
- Contact District staff for modeling data for permitted sources. A public records request may need to be submitted to receive specific permit files.

Highways and Major Roadways:

- Risk, $PM_{2.5}$, and hazard values for highways and major roadways may be further refined with modeling using local traffic and meteorology data. See Section 4.0 in the Modeling Report for additional guidance.

Determine Impacts:

- Compare each source's estimated risk, hazard, and $PM_{2.5}$ to the applicable thresholds as determined by the lead agency. Sum all the sources' impacts for comparison to applicable cumulative thresholds.

Are the risk and hazard estimates below the lead agency's thresholds of significance? Yes → Project can assume no significant impact for risk and hazards. No further analysis needed. No → Implement risk reduction strategies.

Project can assume no significant impact for risk and hazards. No further analysis needed.

Implement risk reduction strategies.

Bay Area Air Quality Management District

EXHIBIT 2

Research Division

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY | AIR RESOURCES BOARD

TECHNICAL ADVISORY

Strategies to Reduce Air Pollution Exposure Near High-Volume Roadways

April 2017

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California Department of Housing and Community Development (HCD)

California Department of Public Health (CDPH)

California Department of Transportation (Caltrans)

California Planning Roundtable

California State Transportation Agency (CalSTA)

California Strategic Growth Council (SGC)

Environmental Investigation Agency (EIA)

European Comission (EC)

Governor's Office of Planning and Research (OPR)

Mutual Housing California

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Santa Barbara County Air Pollution Control District

Santa Barbara County Association of Governments (SBCAG)

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Southern California Association of Governments (SCAG)

Stanislaus Council of Governments (StanCOG)

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University of California, Los Angeles (UCLA)

University of California, Riverside (UCR)

University of Southern California (USC)

U.S. Environmental Protection Agency

Ventura County Air Pollution Control District (VCAPCD)

Table of Contents

Executive Summary

This advisory is a technical supplement to ARB's *Air Quality and Land Use Handbook: A Community Health Perspective* (hereafter referred to as the Land Use Handbook).[1] Published in 2005 under the auspices of ARB's Environmental Justice Stakeholders Group, the Land Use Handbook provides information for local elected officials and land use agencies to consider regarding the siting of new sensitive uses near pollution sources, including (but not limited to) freeways and high-volume roadways, when site-specific air quality information is not available. Since its publication, research has demonstrated the public health, climate, financial, and other benefits of compact, infill development along transportation corridors. Moreover, new research has demonstrated promising strategies to help decrease pollution exposure near their sources. These strategies are the focus of this Technical Advisory.

ARB intends for this Technical Advisory to provide planners and other stakeholders involved in land use planning and decision-making with information on scientifically based strategies to reduce exposure to traffic emissions near high-volume roadways in order to protect public health and promote equity and environmental justice. Many communities in California exist near high-volume roadways. This is both because freeways and other busy traffic corridors have been built adjacent to and through existing neighborhoods in California, and because new developments have been built near existing roadways. Near-roadway development is a result of a variety of factors, including economic growth, demand for built environment uses, and the scarcity of developable land in some areas.

This Technical Advisory demonstrates that planners, developers, and local governments can pursue infill development while simultaneously reducing exposure to traffic-related pollution by implementing the strategies identified here and in other statewide guidance and policies that promote sustainable communities. The State Planning Priorities[2] emphasize infill development, since this pattern of development can help attain goals to promote equity, strengthen the economy, protect the environment, and promote public health and safety. ARB acknowledges that there are many existing developments near high-volume roadways and other sources of air pollution throughout the state, and many of these strategies apply in those situations, as well.

Strategies to reduce exposure include practices and technologies that reduce traffic emissions, increase dispersion of traffic pollution, or remove pollution from the air. Recent research documents the effectiveness of a variety of strategies. Based on a review of this body of research, ARB staff compiled a list of recommended strategies, which this document describes in detail.

This document does not include all potential pollution reduction measures, but rather the options that are well supported by scientific findings and which meet all of the following criteria:

1. Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, or emissions rates, or improving air flow to disperse pollutants.
2. The scientific literature documents evidence of significantly effective exposure reduction.
3. Diversity in the study methods supports consistent findings (such that strategy efficacy does not exclusively rely on one method of investigation).

1 *http://www.arb.ca.gov/ch/handbook.pdf*
2 California Government Code Section 65041.1.

Appendix A outlines strategies that did not meet the ARB's three criteria, but were nonetheless identified in ARB's literature review. In some cases, these strategies represent nascent technologies or designs that require more study before ARB can recommend them for general application. In other cases, studies do not present consistent results or strategies have only been studied via modeling or simulation, and it is uncertain if these strategies will perform similarly in real world settings.

Benefits of compact, infill development

Infill and compact development characterizes many communities located near freeways and other busy traffic corridors. This development pattern has many benefits. It promotes physical activity by facilitating active transportation (biking and walking) and by shortening the distances that people must travel for their daily activities [1]. It also provides density of development that helps support transit operations [2]. The car trips that are shortened or replaced by these other modes result in greenhouse gas (GHG) emissions reductions, and GHGs are further reduced in these communities because they are also associated with reduced energy and water use [3]. Importantly, compact and infill development can also improve people's quality of life by facilitating community connectivity. For these reasons, planners often favor infill and compact development and other stakeholders involved in land use planning and real estate development. Additionally, these types of developments are encouraged by regions striving to achieve greenhouse gas emissions reductions from land use and transportation planning in accordance with Senate Bill (SB) 375.

The foremost strategy for reducing pollution exposure near high-volume roadways is to minimize traffic pollution in the first place. A key mechanism for this is the reduction of vehicle miles traveled (VMT). State legislation including Senate Bills 375 and 743, are specifically designed to facilitate VMT reductions from passenger cars by encouraging and facilitating the replacement of vehicle trips with walk, bike, and transit trips. There is evidence from research and real-world measurement that,

KEY TERMS

traffic emissions

Primary emissions/pollution from motor vehicles, including carbon monoxide, hydrocarbons, nitrogen oxides, particulate matter, toxic air contaminants, brake dust, and tire wear.

high-volume roadways

Roadways that, on an average day, have traffic in excess of 50,000 vehicles in a rural area and 100,000 vehicles in an urban area (Source: California Public Resources Code Section 21151.8).

at-risk populations/communities

Children, pregnant women, the elderly, and those with serious health problems affected by air pollution.

sensitive uses

Land uses where sensitive individuals are most likely to spend time include schools and schoolyards, parks and playgrounds, daycare centers, nursing homes, hospitals, and residential communities.

sustainable communities

Communities that foster conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations.

disadvantaged communities

Communities that score at or above the 75th percentile in the CalEnviroScreen Tool. The tool scores tracts according to their proximity to multiple sources and their vulnerability to the effects of pollution and also account for socioeconomic characteristics and underlying health status.

dispersion (of air pollution)

Distribution of air pollution into the atmosphere.

when vehicle miles and trips are greatly reduced—for example, when streets are temporarily closed to motorized vehicles for car-free open-streets or "ciclovia" events—air quality is significantly improved [4, 5].[3]

Coordinated land use and transportation planning that results in more compact neighborhoods can help reduce VMT by making transit and active transportation viable and reducing the need for personal cars. Travel demand management strategies that improve the efficient use of transportation resources (e.g., teleworking, car-sharing, and carpooling) also reduce vehicle trips. ARB's partners also promote other innovative ideas for increasing the availability and appeal of alternative modes of transportation. At Caltrans, for example, the newly created Active Transportation Program focuses on making California a national leader in active transportation[4] and one Caltrans district is studying freeway capping as an innovative way to better connect people to destinations via parks, paths, and transit constructed atop existing freeways.[5]

In addition to reducing VMT, there are many efforts underway to reduce emissions via other mechanisms. These include more stringent emissions and fuel standards for cars, trucks, and buses; state regulations for zero emission vehicle (ZEV) adoption; and California's Sustainable Freight Transport Initiative. Other state efforts that will reduce emissions, and therefore complement this document, include the AB 32 Scoping Plan and the State Implementation Plan, and the Mobile Source Strategy.

More and more, planners are designing land use developments to make alternatives to automobile travel more attractive. These changes are important because of their long-term significance, as changes in the built environment mean changes in land use patterns that will last for decades. Land use development patterns in some California jurisdictions already contribute to reductions in the use and ownership of cars because of land use planning strategies and active transportation investments. However, change is slow, and many existing and planned developments—including important infill and compact development projects—place sensitive individuals in close proximity to high-volume roadways. In these instances, there is a need for developers, local governments, and other entities to consider pollution reduction strategies to ensure that residents of both new and existing developments breathe air that is as clean as possible.

Need for this Technical Advisory

The primary public health concern regarding roadways near existing and future developments is the possibility that at-risk populations/communities—like children, pregnant women, the elderly, and those with serious health problems affected by air pollution—will be exposed to traffic emissions. In California, there are several instances of schools and other sensitive locations such as daycare facilities located near major roadways, particularly in non-white and economically disadvantaged neighborhoods [6, 7]. Studies show that these populations can experience serious health impacts, including worsening of asthma and cardiovascular disease and adverse birth outcomes because of exposure to traffic-related air pollution. Additionally, studies show that poor and minority communities are more likely to live near busy roadways, and therefore may be more at-risk for the health effects related to exposure to traffic emissions [8, 9].

Scientific evidence indicates that implementing the strategies contained in this document would decrease exposure to air pollution in a variety of locations and contexts, so these strategies are applicable in a broad range of developments, not just those located near high-volume roadways. ARB's motivation for emphasizing these strategies in near-roadway environments is a reflection of the potentially serious health impacts that at-risk populations/communities may experience when they spend significant time in such environments, absent appropriate design measures.

3 "Ciclovias," Open Streets, and Sunday Streets are events whereby roadways are closed to automobiles but open to cyclists and pedestrians. Many cities around the world have implemented these events, including several cities in California: Los Angeles (*http://www.ciclavia.org/*), San Francisco (*http://sundaystreetssf.com/*), San Jose (http://*www.vivacallesj.org/*). Albany, Long Beach, Oakland, Redding, and San Mateo. Visit the California Bicycle Coalition's Web site for more information: *http://www.calbike.org/open_streets*.

4 *http://www.dot.ca.gov/hq/LocalPrograms/atp/index.html*

5 *http://www.dot.ca.gov/dist11/departments/planning/planningpages/capstudy.htm*

In addition, these strategies are likely to yield the greatest public health benefit when applied in near high-volume roadway contexts.

Planners, developers, and others can implement these strategies where existing sensitive uses are already located near high-volume roadways. The strategies are also relevant for new developments. When planners and other decision makers consider these strategies during the planning phase, they may be less expensive to implement than if they are added via retrofits after construction.

How to use this Technical Advisory

ARB envisions that this document will be used by planners and other stakeholders to identify combinations of strategies that can be implemented to reduce exposure at specific developments or to recommend the consideration of these strategies in policy or planning documents. For example, local governments may refer to it or use portions of it in their general plans. The contents may also be helpful in the development or updating of environmental justice policies in general plans, as required by Senate Bill (SB) 1000. Readers interested in learning more about the requirements of SB 1000 should consult OPR's General Plan Guidelines.

It is important to note that this Technical Advisory is not intended as guidance for any specific project, nor does it create any presumption regarding the feasibility of mitigation measures for purposes of compliance with the California Environmental Quality Act (CEQA). Instead, it is meant as guidance for planners weighing options for reducing exposure to traffic emissions.

Strategies to reduce exposure, weighed alongside overarching considerations

The table that follows this executive summary describes the research findings supporting each recommended strategy, the appropriate land use context, and other considerations. These additional items were revealed either through the research or through consultation with experts and stakeholders. This table can be used for quick reference, but readers should also refer to *Section II* for an expanded discussion of these strategies, including details about co-benefits and potential drawbacks.

In addition to the considerations outlined in Section II, readers should be mindful of the following important overarching considerations that were identified by ARB staff and other experts who were consulted during the development of this document:

Changes in land use patterns and the built environment persist for decades

Land use patterns, once established, remain fixed for decades. Increasing density through infill development helps to transform low-density neighborhoods to ones that can support alternative modes. When developing new plans and projects, planners should carefully consider the ongoing influence of those plans and projects on the creation of accessible and livable neighborhoods.

Holistic and comprehensive planning practices

Stakeholders involved in public health, air quality, and community planning efforts must weigh a variety of factors and issues when making policy decisions. At-risk populations/communities' exposure to traffic is just one of many considerations, but it is an important piece that planners and others should weigh alongside other local goals and priorities. Thus, ARB recommends that exposure to traffic emissions and strategies to reduce exposure be considered holistically, within planning processes at the scale of a neighborhood or community plan or ordinance, general plan, sub-regional or regional plan, depending on the geographic impact and regulatory context of the issue. Additionally, ARB recommends that planners consider leveraging holistic and combined practices, policies, and strategies to achieve local goals. Real-world evidence from the Atlanta 1996 Summer Olympic Games showed that a suite of coordinated strategies reduced ozone pollution and childhood asthma events significantly (*see textbox on page 16 for details*).

Site-specific considerations

Site-specific factors may play a significant role in whether or not an exposure reduction strategy will be effective without resulting in negative, unintended consequences. In some cases, it may be possible for planners and other stakeholders to use site-specific information to estimate the reduction in pollution concentration associated with a specific strategy or combination of strategies. When exposure reduction strategies—such as those presented in this document—are incorporated into large-scale policy documents like jurisdiction-wide general plans, a menu of strategies and language about the usefulness of site-specific analysis to assist in choosing the right strategies for specific projects may be appropriate, since not all strategies are necessary or appropriate in all cases.

Changing vehicle fleets and impacts on air quality

California's vehicle fleets and freight system are becoming cleaner and this trend will continue into the future, given existing and forthcoming policies and transformations underway in the automobile market (see more information in *Section I. Introduction*). This fact should be carefully considered in local decision-making, particularly when long-term, durable strategies are being considered, such as urban design changes or standards. It is worth noting, however, that while transitioning to ZEVs eliminates tailpipe emissions, it does not eliminate all traffic emissions. Non-tailpipe particulate matter emissions from road dust, brake dust, and tire wear are likely to continue to impact public health, particularly for sensitive individuals. Furthermore, ZEVs do not eliminate upstream emissions from non-renewable energy sources or sources linked to their manufacture and production [10].

On-roadway exposure to traffic emissions

The more time people spend on roadways, the greater their exposure to emissions that are harmful to their health [11]. This fact should also be considered as planners weigh strategies for reducing near-roadway pollution exposure, since it is crucial that they avoid making land use decisions that would result in longer commutes. In other words, planners should not push new development farther from urban centers because this could induce longer vehicle trips and thus increased on-roadway exposure. Additionally, it should be noted that, in some cases, exposure reduction strategies may increase on-road pollution concentrations. If in-vehicle filtration is inadequate or if drivers travel with the windows down, this could translate into increased exposure for people driving in cars.

Translating research into practice

Putting research into practice can be challenging since research studies often seek to address a narrowly defined question and control for factors that are commonly observed in the real world. The way that research is conducted may not be reflective of real world conditions, so users of this Technical Advisory should consider how the research applies to the specific context being considered. Also, even when data is collected in the real world, the data may be several years old by the time that researchers are able to digest, analyze, and summarize findings and conclusions. Thus, users of this document may need to consider how changes in the local context may have affected the variables that researchers considered in their analyses.

Executive Summary conclusion

The identification of strategies described herein is intended to provide stakeholders involved in public health, air quality, and land use planning efforts (including city and county planners, planning commissioners, developers, planning consultants, and other local government staff and decision makers) with options for reducing exposure to traffic pollution in near-roadway environments, both for existing and new developments. We envision that this document will be used as a resource to:

1. Identify strategies that can be employed on a site-specific basis to reduce exposure to traffic emissions at existing and future developments and;
2. Help shape local policies aimed at reducing exposure to traffic emissions and therefore associated public health impacts.

As California grows, we have the collective opportunity to shape the future of the built environment to be both protective of public health and supportive of environmental goals. ARB hopes that the content of this Technical Advisory will assist the efforts of planners and other practitioners and decision makers to promote healthy, safe, equitable, and sustainable communities. Furthermore, ARB will continue to investigate options to mitigate air pollution exposure in many contexts and related to different sources of air pollution in addition to high-volume roadways.

Table 1: Summary of strategies to reduce air pollution exposure near high-volume roadways

Strategy	Description of research findings	Appropriate context and other considerations
Strategies that reduce traffic emissions		See *Section II*, page 20.
Speed reduction mechanisms, including roundabouts	Vehicle speed reduction mechanisms change the design and operating speed of the road by altering the physical characteristics of the road. These features can reduce stop-and-go driving and hard accelerations and thereby reduce emissions rates. Some of these features, like the roundabout intersection, can be used as an alternative to stop-controlled and signalized intersections. Studies show that roundabouts can reduce localized pollutant concentrations compared to intersections with stop and signal control by 20 percent or more (depending on context and site-specific conditions).	Transportation planners and engineers should carefully consider the potential direct and indirect effects of implementing speed reduction mechanisms to determine if they will reduce vehicle emissions and other impacts to the environment as well as to traveler safety and delay. When guidance is needed to estimate emissions and air quality-related effects, planners and engineers may consult with MPOs or traffic modeling experts.

Strategy	Description of research findings	Appropriate context and other considerations
Traffic signal management	Traffic signal management systems can reduce stop-and-go driving and vehicle idling, resulting in reduced localized pollutant concentrations of up to 50 percent compared to corridors that do not implement these systems. Studies show that site-specific conditions dictate the magnitude of reductions.	Many different types of signal management are available, and planners should identify what is best for air quality, vulnerable road user safety, and transit and active mode throughput and comfort.
Speed limit reductions on high-speed roadways (>55 mph)	Research studies have identified an optimal average speed range of ~35-55 mph within which per-mile traffic emissions and fuel consumption are minimized. Generally, speed limit reductions on high-speed roadways can reduce tailpipe emission rates up to 30 percent, depending on the change in speed, the pollutant measured or modeled, and the roadway characteristics.	Speed limit reductions are appropriate on roadways where speed limit and design speeds exceed 55 mph.
Strategies that increase dispersion of traffic emissions		See *Section II*, page 26.
Design that promotes air flow and pollutant dispersion along street corridors	The physical layout of urban streetscapes influences air flow and pollution movement. Research studies show that street corridors characterized by buildings with varying shapes and heights, building articulations (street frontage design elements like edges and corners that help break up building mass), and spaces that encourage air flow (e.g., parks) benefit from better pollutant dispersion and air quality. For example, buildings of varying heights can result in significant increases in turbulence (e.g., up to doubling), and adding bike lanes and sidewalks not only reduces car traffic, but also creates space for more dispersion (up to a 45 percent reduction in particulate concentrations).	Wider sidewalks, bicycle lanes, dedicated transit lanes, and other features that benefit alternative modes of transportation can also create space for better air flow and pollutant dispersion along with increasing active transportation and mode shift. This strategy should be considered in the context of the overall need to increase development density.

Strategy	Description of research findings	Appropriate context and other considerations
Solid barriers, such as sound walls	Measurement and modeling studies consistently find that solid barriers reduce near-road downwind concentrations by increasing vertical **dispersion** of pollutants emitted by vehicles. The magnitude of the reduction and its spatial extent depend on the height of the barrier, the width of the road, and micrometeorology. Studies have consistently found that pollution concentrations downwind of the barrier range from a 10 percent to 50 percent reduction compared to concentrations measured on or directly adjacent to high-volume roadways.	Solid barriers should only be considered for installation along freeways, because they have the negative effect of dividing neighborhoods and obscuring sightlines.
Vegetation for pollutant dispersion	Studies indicate that vegetation has the potential to alter pollutant transport and **dispersion**. In some studies, specific locations and conditions translated to air quality benefits (e.g., pollution concentration reductions of up to 20 percent on the leeward side of the tree line). It should be noted that most studies were conducted on the East Coast and in Europe where vegetation types and densities differ from what is found in California.	Online tools are available to assist with the selection of appropriate vegetation considering allergen impacts, watering needs, and other factors. Maximum benefits have been shown to occur when vegetation is combined with solid barriers.
Strategies that remove pollution from the air		See Section II, page 36.
Indoor high efficiency filtration	Studies show that particle filtration systems and devices, specifically high-efficiency filtration with mechanical ventilation or portable high efficiency air cleaners, can be highly effective for reducing indoor pollution concentrations. High efficiency filters in ventilation systems can remove from 50-99 percent of particles in the air. However, research shows that filtration technologies for gaseous pollutants (VOCs) are variable in their effectiveness; some remove certain VOCs well, but not others.	Planners should be aware of current state and local building codes and their respective air filtration requirements, including requirements for amending code standards. Regular operation and maintenance is necessary for highest filter and ventilation efficiency, and is required by regulation in commercial buildings.

Introduction

State programs to improve air quality and reduce exposure to traffic emissions

California has a long and successful history of reducing air pollution to protect public health. Gasoline sold in California contains less pollution-forming compounds than most gasoline sold elsewhere in the nation[6], and the low carbon fuel standard is continuing to reduce the carbon content of fuels[7]. California now has more than 100,000 plug-in electric vehicles on its roads, and today's new cars pollute 99 percent less than their predecessors did thirty years ago. ARB's Advanced Clean Cars program will continue to drive reductions in emissions from light-duty vehicles[8]. Emissions from trucks and buses are declining[9], and ambient diesel particulate matter (PM) concentrations in California dropped 68 percent between 1990 and 2012 [12]. These emissions reductions have resulted in significant public health benefits, including the reduction of cancer risk associated with diesel PM.

Reducing traffic emissions

The primary mission of ARB is to protect public health through the improvement of air quality. ARB has many policies and programs to improve near-roadway air quality and to protect public health. These policies and programs primarily rely on technologies or strategies that reduce traffic emissions at the source, which is more effective than attempting to clean up the air after emissions have already been released into the environment. ARB policies and programs focus on traffic emissions because regulation of emissions from stationary sources occurs at local and regional air pollution control authorities known as Air Pollution Control Districts (APCD) or Air Quality Management Districts (AQMD). The following describes State programs that are important for reducing traffic emissions.

The sustainable communities program at ARB focuses on ways to reduce traffic emissions by reducing vehicle miles traveled (VMT). VMT can be reduced through a variety of strategies. Research shows that people tend to drive less when trip origins and destinations can be easily accessed via walking, biking, and transit. Dense, mixed use development is a common way that communities can achieve improved accessibility and mobility without relying on cars.

ARB is responsible for the implementation of the Sustainable Communities and Climate Protection Act of 2008, or SB 375[10]. In accordance with the law, ARB sets regional targets for GHG emissions reductions from passenger vehicle use. In 2010, ARB established targets for 2020 and 2035 for each of the state's metropolitan planning organizations (MPO). To comply with the law, MPOs prepare a "sustainable communities strategy" (SCS) to be included in their regional transportation plans (RTP). The SCS contains land use, housing, and transportation strategies that, if implemented, would allow the region to meet its GHG emission reduction targets. Once adopted by the MPO, the RTP/SCS guides the transportation policies and investments for the region. ARB must review the adopted SCS to confirm and accept the MPO's determination that the SCS, if implemented, would meet the regional GHG targets. As of the writing of this Technical

6 *http://www.arb.ca.gov/fuels/gasoline/gasoline.htm*
7 *http://www.arb.ca.gov/fuels/lcfs/lcfs.htm*
8 *http://www.arb.ca.gov/msprog/consumer_info/advanced_clean_cars/consumer_acc.ht*
9 *http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm*
10 *http://www.leginfo.ca.gov/pub/07-08/bill/sen/sb_0351-0400/sb_375_bill_20080930_chaptered.pdf*

Advisory, all MPOs in California have completed their first SCS/RTP, and most have at least begun the process of completing their second. ARB's Sustainable Communities Web page provides links to SCSs along with ARB staff's technical evaluation. These documents are a useful place for planners to gather information about what is happening at a regional level to reduce VMT and thus air pollution from cars generally.[11]

ARB partners closely with many other state agencies to promote sustainable communities and reductions in VMT and to provide MPOs and local governments with resources that can be used in the development of SCSs and in the implementation of land use and transportation policies at the local level. Partners include Caltrans, the California State Transportation Agency (CalSTA), the Governor's Office of Planning and Research (OPR), the California Department of Housing and Community Development (HCD), and the Strategic Growth Council (SGC). These partners are actively engaged in various programs to reduce VMT. OPR is actively working on promoting VMT reduction by changing the metric used to assess transportation impacts under CEQA, per SB 743[12]. Caltrans is also encouraging shifts from passenger car use toward alternative modes of transportation. The Strategic Management Plan: 2015-2020 contains a statewide VMT reduction target of 15 percent by 2020 relative to 2010 levels and targets to triple biking and double walking and transit by 2020, compared to the 2010-2012 California Household Travel Survey Baseline.[13] Additionally, Caltrans's Active Transportation Program facilitates active transportation programs and infrastructure throughout the state. Caltrans's District 11 (San Diego and Imperial Counties) is also studying freeway capping as a way to use land atop freeways to better connect communities and make walking and biking viable and attractive, and has engaged the local community to consider a future cap over State Route 94.[14]

ARB is responsible for developing statewide programs and strategies to reduce the emission of smog-forming pollutants and toxics by mobile sources. These include both on- and off-road sources such as passenger cars, motorcycles, trucks, buses, heavy-duty construction equipment, recreational vehicles, marine vessels, lawn and garden equipment, and small utility engines.

Looking to the future, ARB's Mobile Source Strategy[15] contains a suite of measures that are being considered to simultaneously meet air quality standards, achieve GHG emission reduction targets, reduce petroleum consumption, and decrease health risk from transportation emissions over the next 15 years. California's Sustainable Freight Action Plan[16] is part of the broader mobile source strategy for on-road heavy-duty vehicles, and includes efforts to reduce nitrogen oxide (NO_x) emissions at the state and federal levels and to encourage freight electrification. Figures 1 and 2 below illustrate both past emission reduction trends and projected future reductions as a result of elements of the Mobile Source Strategy (and based on EMFAC2014[17]).

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11 *https://www.arb.ca.gov/cc/sb375/sb375.htm*
12 *https://www.opr.ca.gov/s_sb743.php*
13 *http://www.dot.ca.gov/perf/library/pdf/Caltrans_Strategic_Mgmt_Plan_033015.pdf*
14 *http://www.dot.ca.gov/dist11/departments/planning/planningpages/capstudy.htm*
15 *http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc_dd.pdf*
16 *http://www.arb.ca.gov/gmp/sfti/sfti.htm*
17 ARB's EMFAC2014 model assesses emissions from on-road vehicles including cars, trucks, and buses in California, and represents ARB's current understanding of motor vehicle travel activities and their associated emission levels.

Figure 1: Statewide annual NO_x emissions (tons/day) between 2000 and 2030 based on EMFAC2014.

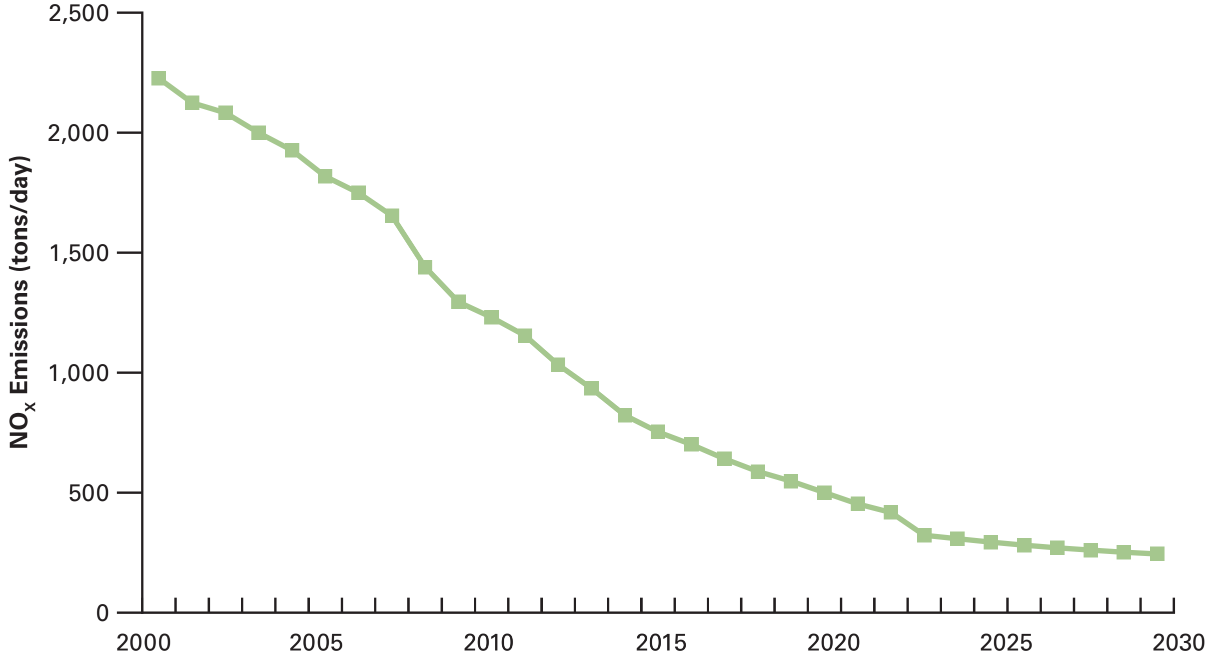
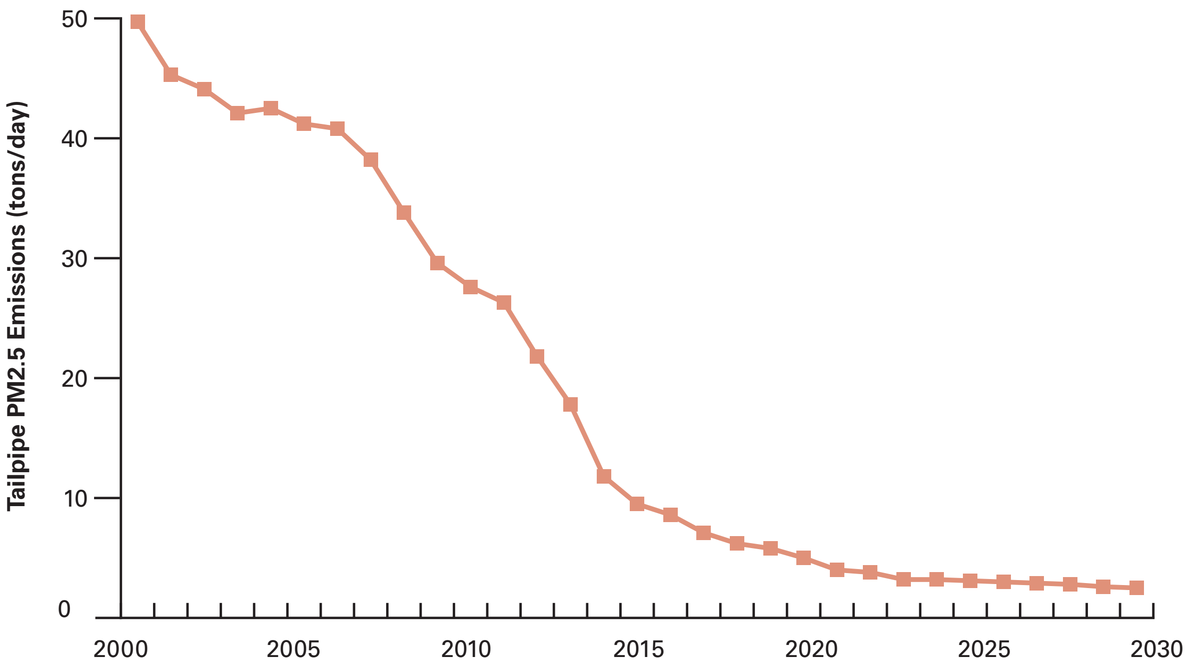


Figure 2: Statewide annual PM2.5[18] tailpipe emissions (tons/day) between 2000 and 2030 based on EMFAC2014.



18 PM2.5 is particulate matter with a diameter of 2.5 micrometers or less.

Reducing exposure to traffic emissions

ARB sponsors research and develops programs and regulations to improve Californians' health by identifying and reducing exposure to air pollutants in both indoor and outdoor environments. Research, sponsored by ARB and others, has revealed a variety of strategies that can be used to reduce exposure when traffic emissions cannot be avoided. These strategies are of great interest to ARB, but it is beyond the authority of ARB to regulate or require that they be implemented. Instead, ARB has historically provided guidance—based on scientific studies and peer-reviewed literature—to agencies with land use authority. In this capacity, ARB has provided guidance on the following, related to reducing the exposure of at-risk populations/communities to traffic emissions.

The 2005 Land Use Handbook recommends that health protective distances (500 feet at minimum, if there is no site-specific information available) be implemented to separate sensitive uses from freeways, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles/day.[19] This recommendation is based on research showing that pollutant concentrations decline significantly as you move farther away from pollution sources, including freeways and other busy traffic corridors [13-15] and epidemiological studies that indicate that spending time in proximity to traffic emissions sources may lead to adverse health effects beyond those associated with regional air pollution in urban areas [16-21].

Much research has taken place since the publication of the Land Use Handbook, and while vehicle emissions rates have declined because of increasingly stringent emissions standards for cars and trucks, recent studies continue to show high near-roadway concentrations and serious health impacts linked to traffic emissions [22-24]. Studies also show that these pollutant concentration gradients can change with traffic patterns, meteorology, and time of day [25, 26, 27-30]. Pollution concentrations near high-volume roadways decline with distance more sharply during the daytime than during the night and the very early morning (i.e., 1-2 hours before sunrise), largely as a result of diurnal meteorological patterns [25, 26, 27, 31]. These research findings—explained in more detail in the text box "*Time-of-day and air pollution concentrations*" (page 20)—highlight the possibility that near-roadway pollution exposure had been previously underestimated and that people living as much as 1,000 feet from freeways were being adversely impacted by poor air quality at night and in the early morning. However, additional research demonstrates that there are alternative strategies that can protect public health while not dictating development patterns.

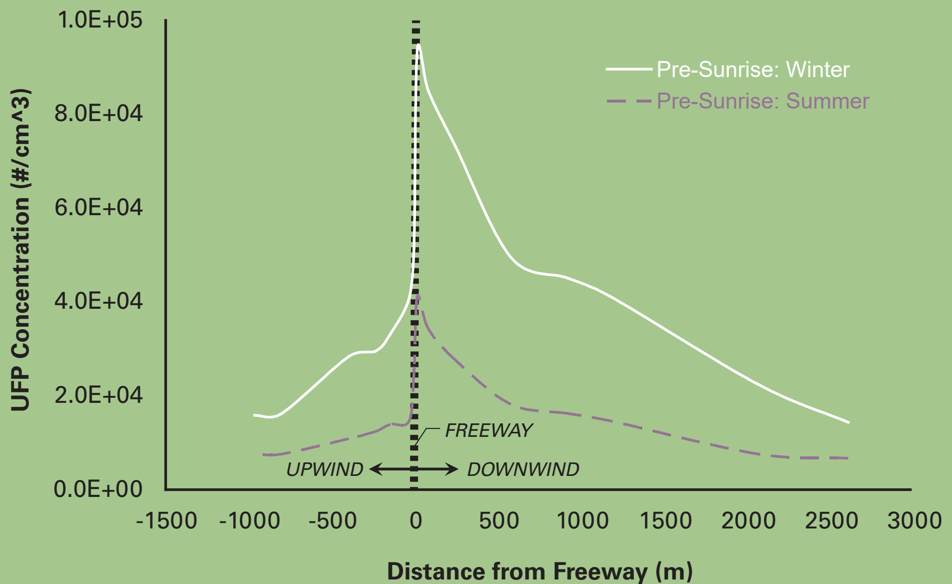
19 *http://www.arb.ca.gov/ch/landuse.htm*

Time-of-day and air pollution concentrations

In a study measuring near-roadway ultrafine particulate matter (UFP) size distributions and concentrations along the Interstate 405 freeway, Zhu et al. [25] found that UFP concentrations decreased with downwind distance from the freeway at night, but at a slower rate than is typically observed during the day.

This finding sparked additional studies to characterize night-time and pre-sunrise pollution concentrations. These studies were motivated by concerns that near-roadway pollution exposure had been previously underestimated and that many people living more than 300 meters (984 feet) from freeways were being adversely impacted by poor air quality at night and in the early morning. Like Zhu et al., these studies found both seasonal and diurnal differences in the rate of decline for pollution concentrations with increasing distance from pollution sources. Winer et al. [32] found that, before sunrise, UFP concentrations did not return to background levels until 2,600 meters (8,530 feet) from the freeway. Later in the morning and afternoon, pollutant concentrations exhibited the typical daytime downwind decrease to background levels within 300 meters (984 feet) downwind of the freeway.

Figure 3: UFP concentrations and gradients along the pre-sunrise route by season. Positive distances are downwind and negative distances are upwind from the I-10 freeway. Image: Winer et al.



Choi et al. [26] observed significant extensions of freeway plumes (~2 kilometers or 1.2 miles) in the stable pre-sunrise periods, much longer than typical daytime plumes measuring ~150-300 meters (~493-984 feet). Also, the researchers calculated a pre-sunrise dilution rate coefficient that is about 10 times lower than dilution coefficient measured during the daytime.

These recent studies highlight the importance of protecting at-risk populations/communities from traffic emissions and indicate that exposure reduction strategies may be needed to protect people that live and spend time in environments that are more than 500 feet from high-volume roadways. This does not mean that nothing should be developed within this distance. In fact, as previously discussed, a compact development pattern is a key strategy in reducing GHG emissions and improving public health through physical activity and it has many other benefits. Instead, planners and developers may want to consider siting non-sensitive uses and developments that will be primarily used and occupied during the daytime—such as commercial uses and offices. In addition to optimizing land use when near-roadway pollution concentrations drop off more sharply with distance, commercial and office buildings are often equipped with indoor filtration systems that can remove particulates from the air inhaled by building occupants, and these buildings are more likely to have permanently closed or sealed windows. This means that, when these buildings are sited close to roads, people that spend time in them are less likely to breathe harmful pollutants and experience negative health impacts. Plus, people typically spend less time at work than at home, meaning that the duration of exposure at work is shorter. These approaches, along with strategies to reduce traffic emissions, disperse pollution and clean indoor air—all discussed in this Technical Advisory—will reduce exposure.

Strategies to reduce air pollution exposure near high-volume roadways

In spite of past successes and ongoing efforts to improve near roadway air quality in California, exposure to traffic pollution is still a concern because pollution concentrations and exposure levels near high-volume roadways continue to indicate that there is a lingering public health concern. In addition, the Office of Environmental Health Hazard Assessment (OEHHA) recently revised its methodology for risk assessment in order to estimate more accurately the health impacts of exposure. This reanalysis has resulted in a revision of cancer risks from exposure to toxic air contaminants, including those emitted by transportation-related sources, to significantly higher levels.[20] ARB forecasting models also indicate that air quality issues will persist even with changes in vehicle technologies and increasingly stringent emissions and fuel regulations. Finally, ARB does not currently regulate non-tailpipe emissions—like tire- and brake-wear—and noise. Scientific literature links these to health effects. Therefore, despite existing efforts they are likely to continue to impact near-roadway public health.

For these reasons, ARB recommends that strategies to reduce emissions, increase dispersion, and remove pollution from the air be implemented to reduce health risks. Many such strategies have been studied and published in peer-reviewed scientific literature. Results can vary based on the specifics of the studies performed, but comprehensive literature reviews conducted by ARB have identified several strategies that consistently and effectively improve air quality and reduce exposure to traffic-related air pollution, particularly where people spend time near high-volume roadways. The specific criteria that ARB used in its evaluation of potential exposure reduction strategies includes the following.

1. Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, or emissions rates, or improving air flow to disperse pollutants.
2. Evidence of significantly effective exposure reduction is documented in the scientific literature.
3. Diversity in the study methods supports consistent findings (such that strategy efficacy does not exclusively rely on one method of investigation).

If literature reviews revealed that all criteria were met, ARB staff included the strategy in this document. In Section II, readers will find a comprehensive discussion of each strategy, including scientific findings and "appropriate context and other considerations."

20 *https://oehha.ca.gov/air/crnr/notice-adoption-air-toxics-hot-spots-program-guidance-manual-preparation-health-risk-0*

Important overarching considerations in selecting strategies

In addition to the strategy-specific considerations outlined in Section II, readers should be mindful of important overarching considerations that were identified by ARB staff and others consulted in the process of compiling these strategies. All of these should be considered regardless of the types of exposure reduction strategies being considered by planners and other users of this document.

Changes in land use patterns and the built environment are changes that last

The durability of the built environment means that land use patterns, once established, remain fixed for decades. This can both help and hinder compact and infill development and the promotion of alternative transportation. In cities like New York, Boston, and Philadelphia, which developed prior to the widespread use of personal cars, established land use patterns have facilitated density and the viability of transit, biking, and walking. Conversely, where a majority of development occurred when personal cars were prevalent, low-density development and separated land uses necessitate driving to access key destinations [3].

Increasing density through infill development helps to transform low-density neighborhoods to ones that can support alternative modes. When developing new plans and projects, planners should carefully consider the ongoing influence of those plans and projects on public health, sustainability, and community goals to support accessible and livable neighborhoods. Some of the exposure reduction strategies listed in this document will have long-term effects on the built environment. In the case where durable changes will be made to the urban fabric, planners should consider how long-run variables might influence their selection from the exposure recommendations strategies recommended by ARB.

Holistic and comprehensive planning practices

Stakeholders involved in public health, air quality, and community planning efforts must weigh a variety of factors and issues when making policy decisions. Vulnerable populations' exposure to traffic is just one of many considerations, but it is an important piece that should be weighed alongside other local goals and priorities. For this reason, it is recommended that exposure to traffic emissions and strategies to reduce exposure be considered within planning processes at the scale of a neighborhood or community plan or ordinance, general plan, and sub-regional or regional plan, depending on the geographic impact and regulatory context of the issue. In this way, planners and other local officials can proactively consider near-roadway factors in their broader, holistic planning processes.

Another important part of holistic planning is considering how combinations of practices, policies, and strategies can be leveraged to achieve local goals. Few scientific studies examine the combined effect of strategies to reduce air pollution exposure, but there is real-world evidence that a suite of strategies yields better results than those implemented in isolation. For example, when multiple strategies were employed to reduce downtown traffic congestion in Atlanta during the 1996 Summer Olympic Games, ozone pollution and childhood asthma events decreased significantly (*see textbox on the next page for more details*).

Additionally, there is evidence that increasing density and urbanization should be implemented in combination with efforts to expand transit, walking, and biking in order to ensure that mobility needs are met without necessitating the use of a vehicle [33-39].

Site-specific considerations

Site-specific factors may play a significant role in whether or not an exposure reduction strategy will be effective without resulting in negative, unintended consequences. Specific factors that are important to consider include topographical, meteorological, and time-of-day factors (e.g., roadway versus development height, wind direction, and pollutant concentration). For example, both traffic management and high efficiency filtration for indoor air may be particularly important

Case study of the 1996 Summer Olympic Games in Atlanta: The impact of changes in transportation and commuting behaviors on air quality

The 1996 Summer Olympic Games in Atlanta, Georgia provided a unique, real-world opportunity to study the traffic, air quality, and public health outcomes of a holistic, integrated alternative transportation strategy. This strategy was developed in preparation for the Games by the City of Atlanta to mitigate anticipated traffic congestion and to enable travel between Olympic events for the more than 1 million visitors. Moreover, Atlanta hoped that the strategy would avoid additional summertime ground-level ozone-related air quality violations. The strategy included a suite of travel-demand management measures, including the following: (1) a 24-hour public transportation system, (2) the addition of 1,000 buses for park-and-ride services, (3) use of alternative work hours and telecommuting by local businesses, (4) the closure of the downtown sector to private cars, (5) alterations in downtown delivery schedules, and (6) public notifications of potential traffic and air quality problems.

Researchers studied the effect of this alternative transportation strategy by comparing the 17 days of the Olympic Games (July 19 – August 4, 1996) to a baseline period consisting of 4 weeks before and 4 weeks after the Games. They looked at citywide acute care visits and hospitalizations for asthma and non-asthma events, concentrations of major air pollutants, meteorological variables, and traffic counts. Results showed decreased traffic density, especially during the critical morning period. This was associated with a prolonged reduction in ozone pollution and significantly lower rates of childhood asthma events [40].

to employ in development along a high-volume roadway where there will be a cumulative pollution burden. Local context is also important; some strategies herein work better in urban environments than in suburban or rural contexts. Drawbacks associated with some strategies may make them unacceptable for a specific site. For example, while stop signs may mean increased emission rates at some intersections, planners may determine that they are more appropriate than implementing a roundabout at that particular location, for a variety of reasons. Also, local planners may wish to eliminate from consideration any strategy that, in the local context, would increase VMT and therefore overall emissions. If such factors are considered as part of a detailed planning process, such as the development of a specific plan, a project-specific or parcel-specific analysis may be avoided.

When strategies are incorporated into large-scale policy documents, such as jurisdiction-wide general plans that direct planning processes for new developments, a menu of strategies and language about the usefulness of site-specific analysis to assist in choosing the right strategies for specific projects may be appropriate, since not all strategies are necessary or appropriate in all cases.

Changing vehicle fleets and impacts on air quality

California's vehicle fleets and freight system are becoming cleaner, and this trend will continue into the future, given existing and forthcoming policies and transformations underway in the automobile market. ARB programs, like those previously noted in the section "State programs to improve air quality and reduce exposure to traffic emissions" (*page 9*), are helping to usher in this transition. This fact should be considered in local decision-making, particularly when long-term, durable strategies are being considered, such as urban design changes or standards.

However, while transitioning to ZEVs eliminates tailpipe emissions, it does not eliminate all traffic emissions. Non-tailpipe particulate matter emissions—like road dust, tire wear, and brake wear—currently account for more than 90 percent of PM10 and 85 percent of PM2.5 emissions from traffic. Both epidemiological and toxicological studies show an association between these pollutants and cardiovascular and pulmonary effects [41]. In a review of published literature examining how the transition to EVs may effect PM10 and PM2.5 emissions, researchers confirmed a positive relationship between vehicle weights and non-exhaust PM emission factors, and also found that ZEVs are, on average 24 percent heavier than equivalent internal combustion engine vehicles (ICEVs) [42]. This makes PM10 emissions from ZEVs roughly equivalent to PM10 emissions from modern ICEVs. PM2.5 emissions from ZEVs are about 1-3 percent less than PM2.5 emissions from conventional cars. This study concludes that, absent efforts to reduce vehicle weights and otherwise mitigate PM emissions, PM10 and PM2.5 levels could remain steady with the EV transition.

Furthermore, ZEVs do not eliminate upstream emissions from non-renewable energy sources or sources linked to their manufacture and production [10]. Using a life cycle approach, some studies have found a modest increase in emissions associated with ZEV production compared to the production of ICEVs [43, 44]. Other studies emphasize the importance of the energy sources used to produce the electricity for ZEVs. They demonstrate that, in some cases, carbon-intense grid mixes can actually translate to greater per-mile CO_2 equivalent emissions from ZEVs relative to conventional cars [44-46].

On-roadway exposure to traffic emissions

Exposure to vehicle emissions also occurs when people use the roadways, whether or not they live or work near them, and past studies show that on-road pollution concentrations can far exceed ambient concentrations. On-road ultrafine particulate matter (UFP) concentrations, for example, typically range from 10,000 to 500,000 particles/cm^3, which is 1-2 orders of magnitude greater than typical ambient levels [15]. These high on-road concentrations mean that people may experience a large proportion of their total daily UFP exposure while driving, depending on where and how long they drive. Based on data from Los Angeles, Fruin et al. [47] found that 36 percent of total daily exposure to ultrafine particulate matter (UFP) resulted from drive time even though only 6 percent of the day (~90 minutes) is spent driving on these roadways by the average Californian. These exposures can be reduced three ways: (1) by reducing on-road concentrations and (2) by reducing time spent driving on roadways, and (3) via in-vehicle air filtration. Reducing time spent driving is an important point for planners to consider, since it is crucial that they avoid making land use decisions that would result in longer commutes. In other words, planners should avoid new development farther from key destinations because this could induce longer vehicle trips and thus increased on-roadway exposure.

Users of this document should also be aware that it is possible that some of the exposure reduction strategies herein—specifically solid barriers and vegetation—could have the effect of increasing on-road pollution concentrations, but study results are mixed [48, 49]. Some field studies that have found increased on-road concentrations attribute this to the possibility that barriers block air flow across the roadway that would, in the absence of a barrier, carry pollution off the roadway. When meteorological conditions and windspeed and direction create the conditions for the entrapment of on-road pollution, some modeling studies also demonstrate this phenomenon. Hagler et al. found that on-road pollution concentrations may increase as barriers grow taller, too [50]. On the other hand, there is also research that contradicts these results. In field studies in Phoenix, AZ, Bauldauf et al. found that concentrations on the highway upwind of the barrier were similar to those measured in the absence of the barrier [51]. These studies suggest that it is very important for planners and others to consider local meteorology when deciding if and how to design certain exposure reduction strategies, which is consistent with the abovementioned overarching consideration regarding the use of site-specific information when it is available and when issues like elevated on-road pollution concentrations are a relevant concern.

While on-road pollution concentrations are concerning, it is also worth noting that many new passenger vehicles are equipped with on-board air filtration that helps to remove particles from the air breathed by the people traveling in the cabin of the car. Xu et al. found that typical commercially available filters exhibit a range of particle removal efficiencies (up to 60 percent), and some thicker filters are even more effective [52]. A study by Zhu et al. found that maximum in-cabin protection from UFPs (approximately an 85 percent reduction in UFP concentration) could be achieved when the in-cabin fan and recirculation settings were on [15]. There are many variables that influence filter efficacy, however, including age, maintenance, and driver behavior when it comes to operating their vehicles. When old filters are not replaced or when windows are open while traveling on roadways, for example, exposure concentrations may be very high [15].

Translating research into practice

Putting research into practice can be challenging since research studies often seek to address narrowly defined questions and control for factors that are commonly observed in the real world. For this reason, research findings may not always be entirely reflective of real world conditions, so users of this Technical Advisory should consider how the research applies to the specific context being considered.

Additionally, even when research is based on data collected in the real-world, the data may be several years old by the time that researchers are able to digest, analyze, and summarize findings and conclusions. For this reason, it may be necessary for planners and the users of this document to consider how changes in the local context may have affected the variables that researchers considered in their analyses. For example, improvements in vehicle technology and controls for diesel emissions from trucks may mean that concentrations of some pollutants are lower today than they were when the data were collected. However, ARB cautions against making assumptions about how health outcomes may be affected by these changes, since health effects are related to a suite of variables, not just emission rates and pollution concentrations.

Ongoing research and other resources

New studies are currently underway and results are constantly emerging from the literature. Appendix A, "Strategies not meeting ARB's criteria at this time" (*page 42*), includes exposure reduction strategies that did not meet all three ARB's following criteria required for inclusion: (1) consistent findings from multiple studies, (2) evidence of significantly effective exposure reduction, and (3) diversity in the study methods used.

In the years to come, these strategies may emerge as promising exposure reduction strategies as a result of additional investigation or updated techniques for more successful implementation.

ARB collaborated with many partner agencies and organizations to produce this Technical Advisory, and in the process, learned of many additional resources that stakeholders will find useful, including the following:

- The United States Environmental Protection Agency (U.S. EPA) sponsors research related to near-roadway air pollution exposure, and as such, recently published a report outlining strategies for reducing exposure at schools. Many of the strategies found in the U.S. EPA document, titled "Best Practices for Reducing Near-Road Air Pollution Exposure at Schools" complement strategies found in this Technical Advisory. To access the U.S. EPA report, visit: *https://www.epa.gov/schools/best-practices-reducing-near-road-air-pollution-exposure-schools.*
- The Bay Area Air Quality Management District (BAAQMD) provides tools, guidance, and information to promote "healthy infill development" from an air quality perspective. The guidance is also intended to encourage Bay Area local governments to consider and address local air quality issues in the planning and development stages. In 2016, BAAQMD published "Planning Healthy Places," which provides recommended best practices for reducing emissions from and exposure to local air pollution sources. BAAQMD's guidebook is accompanied by an interactive web-based mapping tool that illustrates where best practices are recommended and where "further study" is recommended to assess the local concentrations of TACs and fine PM, and therefore the health risks from air pollution" (pg. 12). To access BAAQMD's document and interactive map, visit: *http://www.baaqmd.gov/plans-and-climate/planning-healthy-places.*

ARB encourages users of this Technical Advisory to consult with local air quality experts as they weigh the options presented in this document. Air districts, like BAAQMD may also have useful localized information to aid in the decision-making process. Finally, given the evolving nature of the science, ARB will continue to update documents and websites with the most current information, which can be found at: *https://www.arb.ca.gov/ch/landuse.htm*.

Detailed Description of Strategies to Reduce Air Pollution Exposure Near High-Volume Roadways

This section details strategies to reduce air pollution exposure near high-volume roadways identified by ARB staff from academic literature and ARB-funded research. These strategies are organized into three categories:

1. Strategies that reduce traffic emissions,
2. Strategies that increase dispersion of traffic pollution, and
3. Strategies that remove pollution from the air .

Each strategy presented below includes a description of relevant research findings as well as a summary of the "appropriate context & other considerations" that planners and policy makers should be take into account as they make decisions about which exposure reduction strategies they might include in policy-level documents or on a case-by-case basis. The "other considerations" portion for each strategy also includes a discussion of potential co-benefits and drawbacks.

Strategies that reduce traffic emissions

1: Speed reduction mechanisms, including roundabouts

FINDING: Vehicle speed reduction mechanisms change the design and operating speed of the road by altering the physical characteristics of the road. These features can reduce stop-and-go driving and hard accelerations and thereby reduce emissions rates. Some of these features, like the roundabout intersection, can be used as an alternative to stop-controlled and signalized intersections. Studies show that roundabouts can reduce localized pollutant concentrations compared to intersections with stop and signal control by 20 percent or more (depending on context and site-specific conditions).

APPROPRIATE CONTEXT & OTHER CONSIDERATIONS: Transportation planners and engineers should carefully consider the potential direct and indirect effects of implementing speed reduction mechanisms to determine if they will reduce vehicle emissions and other impacts to the environment as well as to traveler safety and delay. When guidance is needed to estimate emissions and air quality-related effects, planners and engineers may consult with MPOs or traffic modeling experts.

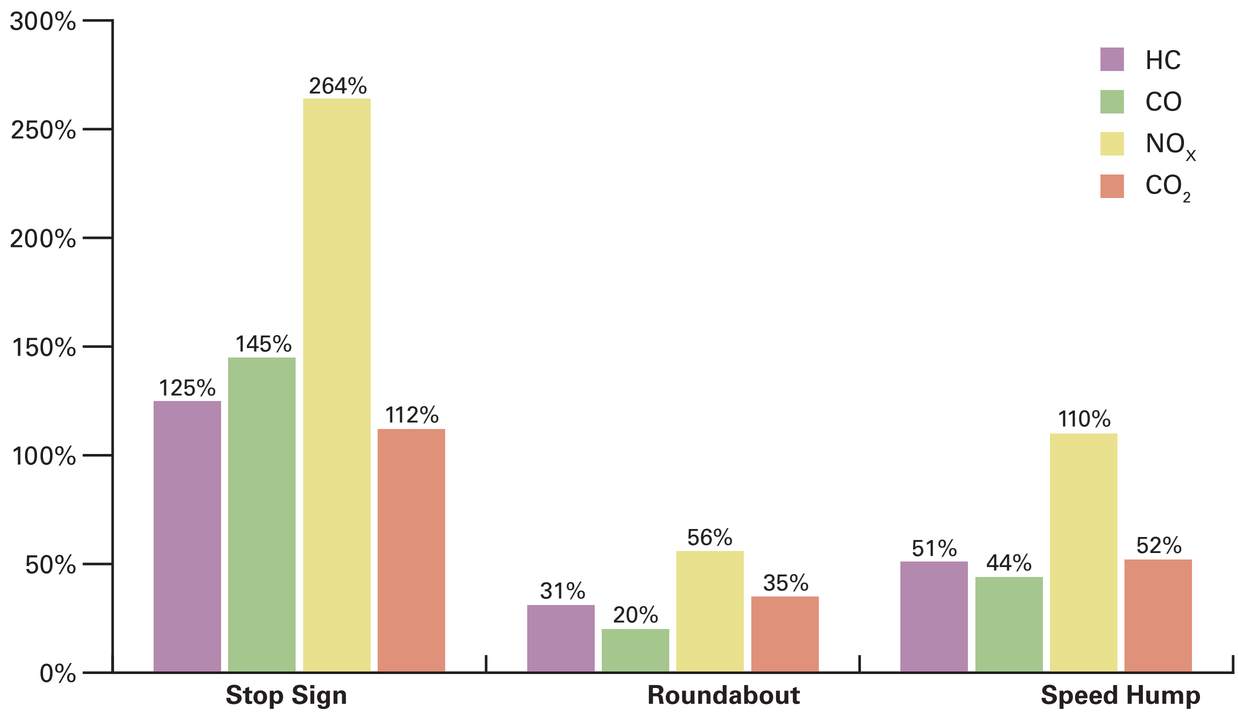
Street, highway, and freeway ramp intersections have been found to be pollution hot spots. This is mainly due to frequent deceleration and acceleration and the increased frequency and duration of idling at intersections. As a result, intersection alternatives that reduce the frequency of stops, acceleration, and idling can generally benefit air quality at and around intersections.

Speed reductions mechanisms, such as roundabouts, can be implemented to smooth traffic flow. Roundabouts can be used in lieu of stop signs or signal controls in order to decrease hard accelerations and decelerations and encourage driving speeds that fall within the optimal range for minimizing emissions rates and fuel consumption. A roundabout is an example of an intersection-specific speed reduction mechanism that can be implemented to reduce pollution concentrations, and produce other transportation system benefits.

Roundabouts

Several studies have found that roundabouts generate substantially less air pollution from vehicles than stop-controlled intersections. Ahn and Rakha [53] found that roundabouts reduce emissions of hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NO_X), and carbon dioxide (CO_2) by 75, 86, 79, and 69 percent respectively, compared to stop-controlled intersections. Figure 4 shows how emissions levels changed compared to a no-control scenario and illustrates how roundabouts and speed humps—another speed reduction measure—compare to a two-way stop controlled intersection (with stop signs on the minor leg approaches). These data were produced using a mathematical model that estimates emission rates using second-by-second speed and acceleration measurements collected by researchers at a specific intersection located in Arlington, VA.

Figure 4: Relative increases in emissions for various intersection treatments (compared to no treatment) as measured at an experimental site in Arlington, VA. Image derived from: Ahn and Rakha 2009.



Höglund [54] found when a traffic signal intersection was changed to a roundabout, the HC emission per vehicle per kilometer travelled decreased by 36 percent. Várhelyi [55] used the "car-following" method and showed that replacing a signalized junction with a roundabout decreased CO emissions from vehicles by 29 percent, NO_X emissions by 21 percent, and fuel consumption by 28 percent. Mandavilli et al. [56] found a statistically significant decrease in the emissions from vehicles when a modern roundabout replaced a stop-controlled intersection for six sites with different traffic volumes. In particular, the reductions were 21-42 percent for CO, 16-59 percent for CO_2, 20-48 percent for NO_X and 17-65 percent for HC.

While the research literature shows mostly positive performance results for roundabouts from the emissions and air pollution perspective, some studies illuminate their limitations. Ahn et al. [57] find that, at the intersection of a high-speed road with a low-speed road, an isolated roundabout does not necessarily reduce vehicle fuel consumption and emissions compared with other forms of intersection control (stop sign and traffic signal control). In fact, the case study found that the roundabout in this context results in a significant increase in vehicle fuel consumption and emission levels compared with a two-way stop. The researchers attribute this finding to the fact that, as demand increases, traffic at the roundabout experiences a substantial increase in geometric delay (the increase in travel time as vehicles must navigate the roundabout more slowly) in comparison with the use of signal control.

Appropriate context & other considerations

It is important that speed reduction mechanisms and roundabouts be evaluated with site-specific conditions and context in mind in order to ensure that these road design elements achieve sought-after emissions reductions and other benefits. Many resources are available to assist with the selection, planning, and design of speed reduction mechanisms and roundabouts, including (but not limited to) the following:

- FHWA Roundabout Website: *http://safety.fhwa.dot.gov/intersection/roundabouts/*
- Roundabouts: An Informational Guide, Second Edition (NCHRP Report 672):
- *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf*
- National Association of City Transportation Officials Urban Street Design Guide: *http://nacto.org/publication/urban-street-design-guide/design-controls/design-speed/*
- AASHTO's Strategic Highway Safety Plan: *http://safety.transportation.org/htmlguides/speeding/section01.htm*
- FHWA Roundabout Outreach and Education Toolbox: *http://safety.fhwa.dot.gov/intersection/roundabouts/roundabouttoolbox/*

Depending on site-specific conditions, speed reduction mechanisms can result in improved safety; specifically, fewer fatal crashes and less serious injuries when crashes occur. The FHWA Office of Safety identified roundabouts as a Proven Safety Countermeasure because of their ability to substantially reduce the types of crashes that result in injury or loss of life. Roundabouts reduce vehicle speed and the number of conflict points at the intersection, which provides safety benefits for vehicles, pedestrians, and bicycles. Single lane roundabouts produce the lowest vehicle speeds and fewest number of conflict points compared to multi-lane roundabouts and traditional signal and stop-controlled intersections. The FHWA document, "Roundabouts: An Information Guide,"[21] states, "While overall [and especially severe] crash frequencies have been reduced, the crash reductions are most pronounced for motor vehicles, less pronounced for pedestrians, and equivocal for bicyclists, depending on the study and bicycle design treatments" [58-60].

While roundabouts are not expected to reduce vehicle emissions at all intersections (refer to above mentioned case study by Ahn et al.), [57] roundabouts have been proven to be effective at freeway interchange ramp terminals. FHWA guidance indicates that roundabouts can help create a transition area that moves traffic from a high-speed to a lower-speed environment.

Regarding design and engineering requirements for roundabouts, Caltrans and FHWA provide guidance to help local planners and engineers, including the following:

- The California Manual of Uniform Traffic Control Devices (MUTCD) provides standard guidance on roundabouts as an alternative to traffic signal control; see Part 4, Chapter 4C, Section 4C.01 Studies and Factors for Justifying Traffic Control Signals.[22]
- The Caltrans Intersection Control Evaluation (ICE) Policy Directive (TOPD13-02) and website provide direction and guidance on the evaluation of highway project proposals that create new, and expand or modify existing, intersections and interchanges. Caltrans established ICE to ensure the objective consideration, evaluation, and comparison

21 *https://www.fhwa.dot.gov/publications/research/safety/00067/index.cfm*
22 *http://www.dot.ca.gov/trafficops/camutcd/*

of roundabouts with traditional and other innovative intersection solutions.[23]

In all cases, roundabouts should be designed to satisfy the engineering principles outlined in the FHWA Informational Guide on Roundabouts, published as NCHRP Report 672.[24] This will generally produce the range of vehicle speeds that are capable of reducing vehicle emissions and the potential for crashes (as described above). Local and other agencies responsible for the operation of streets and highways are advised to employ qualified traffic analysts and engineers to evaluate, design and oversee their first roundabouts. Roundabout implementation in some communities may require consultation with local agencies that may be affected by these intersections, including (but not limited to) operators of transit, waste disposal, delivery, and emergency response vehicles. Planners should also consult with their local air quality management district to see if it provides additional recommendations for this type of strategy.

It is advisable to establish an education campaign for communities that are planning to construct roundabout intersections for the first time to accelerate understanding and acceptance of roundabouts in communities that do not yet have a modern roundabout intersection. This can inform travelers and others who will be affected by a roundabout of other advantages and co-benefits attributed to roundabouts (e.g., roundabouts can improve aesthetics and reduce operating & maintenance costs compared to signalized intersections).

2: Traffic signal management

FINDING: Traffic signal management systems can reduce stop-and-go driving and vehicle idling, resulting in reduced localized pollutant concentrations of up to 50 percent compared to corridors that do not implement these systems. Studies show that site-specific conditions dictate the magnitude of reductions.

APPROPRIATE CONTEXT & OTHER CONSIDERATIONS: Many different types of signal management are available, and planners should identify what is best for air quality, vulnerable road user safety, and transit and active mode throughput and comfort.

Traffic lights are widely used at intersections to reduce traffic speed, avoid traffic accidents and crashes, and improve safety for road users. However traffic lights can also increase idling, deceleration, and acceleration of vehicles, and therefore increase air pollutant emissions from vehicles. Coelho et al. [61] found the presence of traffic signals can increase CO, NO, and HC emissions from vehicles by about 15 percent, 10 percent, and 40 percent, respectively. Different traffic signal schemes may have different impacts on vehicle emissions [62]. Signal strategies that prioritize enforcement of the speed limit may result in more stops for all traffic, and therefore lead to higher emissions from vehicles. Signal strategies that are more tolerant on speed enforcement may achieve lower emissions.

Traffic signal coordination has been found to be a potentially effective strategy to reduce vehicle emissions by several modeling studies. Rakha et al. [63] found a well-timed green wave (all vehicles only need to stop at the first traffic signal along a road section) can reduce the emissions of HC, CO, and NO_X from vehicles by 50 percent, compared with extreme cases of all vehicles having to stop at all signals. De Coensel et al. [64] simulated vehicle emissions for an urban arterial road with a speed limit of 50 kph, and five consecutive traffic signals spaced at a distance of 200 m from each other. This study found that the introduction of a green wave could reduce the emissions of CO_2, NO_X, and PM10 by 10-40 percent. The largest reduction of vehicle emissions may be achieved when traffic intensities are close to road capacity and the green split (the ratio between the amount of green light time and the traffic light cycle time) is high. The introduction

23 *http://www.dot.ca.gov/trafficops/ice.html*
24 *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf*

of a green wave also reduced noise levels near traffic signals; however, noise levels between intersections increased. A study in China showed that, by increasing the green split of the major direction by 5 percent, the emissions of CO, HC, and NO_x of different vehicle categories decreased in the range of 2.6-14.6 percent [65].

Positive environmental impacts of traffic signal coordination have also been confirmed in measurement studies. Unal et al. [66] performed on-board air pollutant emission measurements along two signalized arterial roads in North Carolina and found that, depending on the type of vehicles and the level of congestion, the implementation of traffic signal coordination reduced the HC, NO, and CO emissions per unit of distance by 10-20 percent. Similarly, Zhang et al. [67] measured the NO_x, HC, and CO emissions from a single vehicle driven on two roads that were similar except one had coordinated traffic signals. The results showed that the emissions of HC and CO per kilometer travelled decreased 50 percent and 30 percent, respectively, along the road with coordinated signals, but the emission of NO_x per kilometer travelled was 10 percent higher.

Appropriate context & other considerations

It is important that planners consider site-specific factors and consult with guidance material and traffic experts before deciding to implement traffic signal management strategies. The following resources (and others) are available to assist with the selection, planning, and design of traffic signal management systems:

- FHWA Traffic Signal Timing Manual: *http://ops.fhwa.dot.gov/publications/fhwahop08024/fhwa_hop_08_024.pdf*
- Signal Timing Manual: Second Edition (NCHRP Report 812): *http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_812.pdf*

When implemented with site-specific context and other goals in mind, traffic signal management can improve safety and enable efficient movement of transit vehicles and bicycles. Regarding safety, several studies have found that coordinated signals can reduce the frequency and severity of automobile crashes. A field evaluation in Scottsdale, Arizona found that coordinated traffic signals resulted in a crash risk reduction of 6.7 percent [68] and studies from Europe found that network coordinated signals were associated with a 20 percent reduction in injury accidents at intersections [69]. Based on data from 1,345 crashes at three arterial intersections in Indiana, Li and Tarko [70] used a mixed logit model to find that crashes and severe crashes are less likely at intersections with signal coordination. Finally, a study in Phoenix, Arizona assessed five years of crash data (1993-1997) and found that crash rates at coordinated traffic signals were less than those for uncoordinated traffic signals by 14 to 43 percent.

Coordinated signals can also be designed to more efficiently move transit vehicles and other modes. With the technological infrastructure in place, coordinated traffic signals can be programmed to work in concert with transit vehicles. Recent advances in intelligent transportation system technology have made it possible for transit vehicles to communicate with signal timing infrastructure, so coordinated signals could be dynamically adjusted to allow more efficient movement of transit vehicles which not only makes them more attractive to transit riders but also reduces diesel particulate emissions from these heavy-duty vehicles. Coordinated signals can also be timed to accommodate cyclists and to give them a “green wave” along with motorists.

It is important for planners and others to consider potential effects of traffic signal management strategies when deciding if and where this exposure reduction strategy may make sense. For example, this strategy loses effectiveness when implemented where traffic volumes on cross-streets are comparable with those on the managed section. This will result in increased idling on these perpendicular sections and thus accumulating traffic emissions.

Additionally, it is possible that coordinated signals will increase vehicle throughput and VMT on the road section where it is implemented, since this strategy increases the “effective” capacity of the roadway section. Some models have shown that increased throughput is VMT shifted from elsewhere while others attribute increased VMT to new trips generated by the increased effective capacity. Dowling [71] analyzed the net effects of a 0.5 mile long arterial signal coordination project and found that, regionally, VMT is actually reduced by -0.01 percent and emissions by 0.02-0.04 percent as a result of the project. More studies are needed to understand the broad and long-term impacts of traffic signal synchronizations, and local traffic engineers may have information that will make it possible for planners to implement this without offsetting air quality gains with increased vehicle use.

Finally, pedestrian crossings are an important consideration for traffic signal management projects. The FHWA Traffic Signal Timing Manual indicates that the time needed to serve vehicle volume is usually commensurate with a reasonable amount of wait-time for pedestrian calls, but planners should evaluate this on a site-specific basis to ensure that traffic signal coordination and the resultant timings for pedestrian crossings do not curb overall pedestrian activity.

Planners should also consult with their local air quality management district to see if it provides additional recommendations for this type of strategy.

3: Speed limit reductions on high-speed roadways (>55 mph)

FINDING: Research studies have identified an optimal average speed range of ~35-55 mph within which per-mile traffic emissions and fuel consumption are minimized. Generally, speed limit reductions on high-speed roadways can reduce tailpipe emission rates up to 30 percent, depending on the change in speed, the pollutant measured or modeled, and the roadway characteristics.

APPROPRIATE CONTEXT & OTHER CONSIDERATIONS: Speed limit reductions are appropriate on roadways where speed limit and design speeds exceed 55 mph.

Studies show that high speeds encountered on highways require high power output from vehicles, and this is associated with increased per-vehicle tailpipe emissions rates. Several studies have evaluated the role that speed limits play in vehicle speeds and air quality. Keller et al. [72] conducted a modeling simulation to investigate the emission impact of lowering the maximum speed limit on Swiss motorways from 120 to 80 kph (75 to 50 mph). The models predicted current total NO_X release from road traffic would decrease around 4 percent, peak ozone levels may decrease by less than 1 percent, and no significant change in emissions of VOCs. Similarly, Gonçalves et al. [73] simulated the effects on vehicle emissions of the 80 kph (50 mph) speed restriction planned for the Barcelona Metropolitan area, and found the reductions on NO_2, NO_2, and PM10 levels on the affected roads reached up to 5.7 percent, 5.3 percent, and 3.0 percent on 24-h average concentration, respectively. Field measurements also confirmed the reductions of traffic-related air pollutant levels with lower speed limits. A Netherlands study monitored the changes of traffic related air pollutant levels in the direct vicinity of a highway after lowering the maximum speed limit from 100 to 80 kph (62 to 50 mph) [74]. This study found the adjusted traffic contribution to air pollutant concentrations in the vicinity of the intervention site significantly decreased by 27 percent, 11 percent, and 21 percent, for PM10, PM2.5, and black smoke, respectively.

Additionally, studies indicate that higher vehicle speeds are also associated with increased non-tailpipe emissions, including higher rates of tire wear and associated PM emissions and greater resuspension of road dust [75, 76]. Related to tire wear, researchers have measured increased PM emissions with increasing vehicle speed and have hypothesized that, as tire temperature increases with faster speeds, tires break down more readily [77]. Studies also show that more road dust tends to be re-suspended into the air when vehicles travel faster [76]; Kuhns et al. found that road dust emissions increase exponentially with increasing vehicle speeds [78].

Appropriate context & other considerations

Planners should consider the direct and indirect effects—including benefits and drawbacks—involved in reducing posted speed limits on high-speed roadways to less than 55 mph. Planners should also consult with their local air quality management district to see if it provides additional recommendations for this type of strategy.

Higher vehicle speeds are associated with increased risk of severe crashes and injury or death when crashes occur [79, 80]. Thus, reducing speed limits to 55 mph or less on freeways could result in safety benefits for roadway users. This assumes, however, that drivers respond to speed limit reductions. In actuality, changing the speed limit does not necessarily translate to a change in vehicle speed, as the majority of drivers drive at speeds at which they feel comfortable. This means that speed limit reductions may need to be implemented in conjunction with additional enforcement in order to ensure that drivers adhere to new speed limits. Enforcement can be implemented via police, radar, camera, or aircraft, but this comes with associated costs.

Research also indicates that the ratio of in-cabin to on-roadway pollution concentration ratios—or I/O ratios—increase with increasing vehicle speed because faster driving speed creates a larger pressure differential between the in-cabin and outside air. This causes more air exchange into the cabin from outside, and therefore exposes the people traveling in the cabin to higher pollution concentrations [81]. Xu et al. measured in-cabin I/O ratios for UFP and found that the largest UFP penetration factor and the largest I/O ratios were measured at the fasted driving speeds [52]. Thus, reducing in-cabin exposure to traffic related pollution may be a co-benefit of reducing speed limits for near-roadway exposure reduction purposes.

Strategies that increase dispersion of traffic pollution

To date, several studies and literature reviews have evaluated how urban design in the built environment influences air pollutant levels in streetscapes [82-92]. While the majority of these are modeling studies conducted to understand air flow and pollutant dispersion in urban street canyons, they also show that urban design characteristics—including building geometry, architectural design, street canyon dimensions, and building siting—are important parameters that influence pollutant dispersion, concentration, and exposure [82, 86]. Also, a select few have identified urban design guidelines to reduce pollutant exposure [91, 93-95].

4: Design that promotes air flow and pollutant dispersion along street corridors

FINDING: The physical layout of urban streetscapes influences air flow and pollution movement. Research studies show that street corridors characterized by buildings with varying shapes and heights, building articulations (street frontage design elements like edges and corners that help break up building mass), and spaces that encourage air flow (e.g., parks) benefit from better pollutant dispersion and air quality. For example, buildings of varying heights can result in significant increases in turbulence (e.g., up to doubling), and adding bike lanes and sidewalks not only reduces car traffic, but also creates space for more dispersion (up to a 45 percent reduction in particulate concentrations).

APPROPRIATE CONTEXT & OTHER CONSIDERATIONS: Wider sidewalks, bicycle lanes, dedicated transit lanes, and other features that benefit alternative modes of transportation can also create space for better air flow and pollutant dispersion along with increasing active transportation and mode shift. This strategy should be considered in the context of the overall need to increase development density.

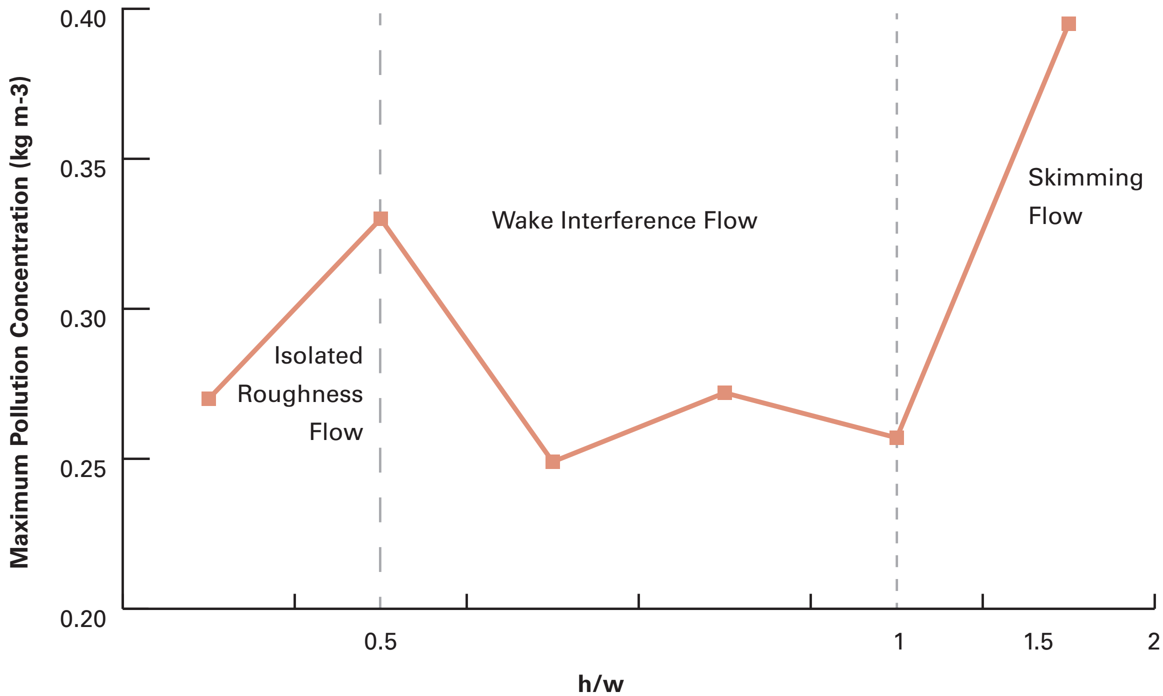
Research shows that the physical layout of urban streetscapes influences how air flows and pollutants move, and thus, planners can use this to their advantage to design buildings and streets to facilitate pollution dispersion [83, 84, 96, 97]. Key variables that planners can consider include the size, shape, and location of building and streets. This section outlines findings from modeling studies (e.g., wind tunnel simulations, computational fluid dynamics modeling, etc.) and field and measurement studies that shed light on the influence of these variables.

Many studies focus on evaluating pollutant behavior in “urban street canyons” characterized by narrow streetscapes continuously lined with buildings because they often experience “hot spots” of gaseous and particulate pollutants due to high levels of vehicular traffic and reduced ventilation flow created by the street canyon configurations themselves [98, 99]. In California, there are very few cities with traditional urban street canyons, and as such, concerns about pollution hot spots that have been raised in other cities—like Hong Kong and Manhattan—may not be relevant for current California cities. Nevertheless, the studies discussed herein can inform design choices that reduce pollutant exposures by maintaining or increasing ventilation and air flow as California’s cities continue to grow and develop.

Developing uniform characterizations of pollutant dispersion and concentration in urban street canyons is challenging because differences in canyon geometry, traffic intensity and fleet mix, and local meteorological conditions translate to an almost infinite set of combinations and air quality outcomes [82, 89, 100]. While arriving at rigid guidelines for altering urban design to reduce air pollution is extremely difficult given this complexity, researchers have endeavored to identify various critical configurations to avoid when concerned about pollution concentrations [84, 100, 101]. These recommendations align with findings from studies that model the flow of pollutants through urban areas.

Numerous studies have investigated the close link between air vortex circulations that develop within the canyons and pollutant dispersion. Modeled and measured research confirms that when roof-level wind flows perpendicular to the street, a vortex circulation develops, resulting in much higher pollution levels on the downwind side of the street canyon [82, 87, 100, 102-108]. These circulation vortices are also influenced by street canyon geometry, and one variable used to measure this geometry is called the “aspect ratio” [89]. In canyon flow studies, the aspect ratio—the ratio of the building height to the width between buildings—is generally accepted as the key factor determining wind flow characteristics [83, 85, 93, 109]. Research shows that aspect ratios that describe canyons that are wider relative to their height promote better pollutant dispersion because they provide more space for ventilation flow to reach the street level [84, 100, 110-113]. This is not to say that tall buildings necessarily promote blockage, however. Using dispersion modeling validated against measurements from wind tunnels, Chan et al. [100] found that—with a fixed reference speed and fixed building height—as the street width is increased, pollutant concentrations decrease on both the upwind and downwind sides of the street. As long as the canyon aspect ratio creates a turbulence pattern that falls between stagnation flow and leeward blockage, ventilation will be promoted [84]. Figure 5 below demonstrates this concept by showing how pollution concentrations change with varying height-to-width ratios (h/w).

Figure 5: There are three air flow regimes in urban areas that are denoted in the figure: isolated roughness flow (generally more ventilation), wake interference flow (some ventilation), and skimming flow (little to no ventilation). The figure demonstrates that street canyons with higher height-to-width ratios tend to have higher pollutant concentration. To avoid this, ARB suggests that street canyons have space for better ventilation and/or implement strategies to reduce emissions produced. Image: Chan et al. 2001.



Studies also show that open space can increase ventilation over the city fabric [91, 114, 115]. Kaur et al. [114] found that particulate concentrations are two times higher at intersections surrounded by buildings compared to intersections adjacent to open space. Hess et al. [115] examined pollutant concentrations inside and outside seven bus stop locations in Buffalo, New York and found that the presence of undeveloped areas without vehicle access on both sides of the bus shelter or without a building on one side provide statistically significant reductions compared to a bus stop site with buildings on both sides of the street.

In addition to canyon geometry, building variables—including height, width, and roof shape—also influence air flow and pollutant dispersion. Some studies find that building uniformity (e.g., height and breadth) decreases air flow [83, 84, 89], and others find that gaps between adjacent buildings facilitate air flow and ventilation [116-118]. Roof shape and height can also influence air flow [30, 106, 119, 120]. Xie et al. used both 2D and 3D modeling to simulate the effects of different roof shapes and building geometries on vehicle emissions dispersion [106]. They found that different roof shapes lead to different circulation vortices and thereby influence air quality in the urban canyon. Huang found similar results when investigating the impact of wedge-shaped roofs on pollutant dispersion [30].

Boarnet et al. studied the effect of both canyon geometry and building characteristics on pollutant concentrations in five cities in Southern California [111]. The researchers measured PM2.5 concentrations near arterials in five cities that exhibit different development patterns, ranging from low-density auto-oriented development to dense urban areas with mid- and high-rise buildings. A regression analysis of the measurements indicated that—after accounting for meteorology, time of day, and location—higher concentrations were associated with lower wind speeds, higher temperatures, higher adjacent passenger vehicle traffic, higher ambient concentrations, and street canyons with buildings over five stories.

While there is a large body of research that explores the interaction between building and street design and air flow, only a few studies quantify the pollution reduction. Chan et al. applied the urban form guidelines they developed through their modeling efforts to a hypothetical situation and modeled the effect of these building configuration modifications in a small district in Hong Kong [83]. These modifications included (1) altering the relative building heights—including by adding height to some buildings—to create differential heights and (2) altering the building breadth ratio. The modeled pollution levels dropped by 40 percent and 30 percent, respectively.

Acero et al. used dispersion models to calcuate NO_2 concentrations associated with three different urban design features—a park with trees, an open space with obstacles, and a building—in the medium-sized town of Durango, Spain [121]. The study found that removing the park with trees to leave an open space reduced NO_2 concentrations on the eastern part of the street by about 6.1 percent. On the other hand, the presence of a 16 meter (52 foot) building instead of trees created a recirculation vortex. This dispersed local traffic pollutants to the western side of the street, close to the new building, with the wind direction influencing the spatial variation of pollutants. This study illustrates the importance of local wind direction and orientation to the dispersion of polluants.

Schulte et al. [113] developed and evaluated a semi-empirical dispersion model to estimate surface concentrations of NO and NO_2. This was accomplished using empirically collected data from street canyons in Hanover, Germany to evaluate dispersion models and identify the variables that best describe the observed data. The researchers concluded that the ratio of effective building height to street width governs the dispersion of vehicle emissions. The researchers also presented three possible methods for mitigating street-level pedestrian exposure to vehicle emissions: (1) limiting vehicle traffic within streets with large aspect ratios when there is high pedestrian traffic, (2) limiting the street aspect ratio based on expected pedestrian exposure, and (3) in new developments, or where such design can be implemented, separate pedestrian and heavy vehicle traffic into different streets.

Appropriate context & other considerations

The research literature demonstrates that design that promotes air flow and pollutant dispersion along street corridors can take many forms. Implementing complete streets design concepts—which are characterized by wider sidewalks, bike routes or paths, and transit lanes or infrastructure—is an option that both facilitates air flow and encourages active transportation and alternative modes. Complete streets designs also have the potential to reduce VMT and therefore emissions along a corridor, particularly when vehicle lanes are converted to provide the infrastructure for alternative modes.

A recent ARB study that compared existing complete streets and “incomplete streets (streets that did not exhibit the characteristics of complete streets) found that the former may be positively associated with reductions in UFP, lower vehicle traffic volume, and more pedestrians and cyclists [122]. The research concluded, however, that these outcomes are not always a given with complete streets; context and design play an important role in influencing the direction and magnitude of the benefits. The researchers recommend prioritizing construction of complete streets in downtowns, business areas, and locations that create a contiguous network of bike, pedestrian, and transit infrastructure.

Other valuable sources of information on how to maximize the desired benefits of complete streets implementation are available from the National Association of City Transportation Officials (NACTO). Several NACTO publications provide guidance on how to design urban streets, transit streets, and urban bikeways, and include case study examples.[25] Planners should also consult with their local air quality management district to see if it provides additional recommendations for this type of strategy.

25 *http://nacto.org/*

Increasing active transportation may lead to additional health benefits that are associated with increased physical activity [123]. Also, complete streets can improve the street aesthetic, increase property values, and promote business visibility.

The literature also shows that siting or preserving parks can also improve air quality along street corridors, but care should be taken when deciding what park facilities will be installed and where these facilities should be located. For example, playgrounds or recreation fields should be located away from heavily-trafficked routes to protect children and others from concentrated emissions.

Lastly, this strategy should be considered in the context of the overarching goals to increase development density and infill. Planners should consider how this strategy can be used without spurring more dispersed development, which is associated with more vehicle travel and thus more emissions, which would undercut the environmental and health benefits. In some cases, it may be necessary to implement this strategy in specific areas in concert with other measures that will ensure that broader goals are still supported.

5: Solid barriers, such as sound walls

FINDING: Measurement and modeling studies consistently find that solid barriers reduce near-road downwind concentrations by increasing vertical dispersion of pollutants emitted by vehicles. The magnitude of the reduction and its spatial extent depend on the height of the barrier, the width of the road, and micrometeorology. As reference, studies have consistently found a concentration deficit downwind of the barrier, ranging from a 10 percent to 50 percent reduction compared to concentrations measured on or directly adjacent to high-volume roadways.

APPROPRIATE CONTEXT & OTHER CONSIDERATIONS: Solid barriers should only be considered for installation along freeways because they have the negative effect of dividing neighborhoods and obscuring sightlines.

Field measurement studies generally show that solid barriers, such as sound walls, can effectively and significantly reduce near-road pollution concentrations for a variety of traffic air pollutants [48, 51, 124-127]. Baldauf et al. measured concentrations of NO_X, PM, and air toxics behind a 1 km long barrier along Interstate I-440 in Raleigh, NC using a mobile platform and fixed sampling instruments. The study revealed that CO and PM number concentrations generally decreased between 15-50 percent behind the barrier [48]. Ning et al. also measured lower pollution concentration reductions where barriers were present along I-710 and I-5 in Southern California, compared to where they were not present [125]. Finally, a more recent field study in Phoenix, AZ—which measured NO_2, CO, UFP, and black carbon (BC) using both a mobile platform and fixed sites—found that pollutant concentrations behind the roadside barriers were significantly lower relative to those measured in the absence of barriers. The reductions ranged from 50 percent within 50 meters (~164 feet) from the barrier to about 30 percent as far as 300 meters (984 feet) from the barrier [51].

Modeling and wind tunnel studies, like the field studies mentioned above, also consistently find that barriers result in reduced concentrations beyond the barrier [50, 127-129]. Heist et al. conducted a wind tunnel experiment that modeled 12 configurations with and without barriers and found that all with-barrier configurations reduced the downwind ground-level concentrations compared to no-barrier configurations, though the magnitude of the reduction varied depending on the specific conditions [129]. Hagler et al. created a model to mimic the wind tunnel experiments conducted by Heist et al. and used it to observe the effect of changing variables—like the barrier height and wind direction—to test how near-roadway concentrations of pollutants might change with these different variables. The model found decreased concentrations downwind of the barrier and estimated that higher barriers would result in greater downwind reductions [50].

The South Coast Air Quality Management District recently funded a study to investigate the effect of roadside barriers on dispersion from roadways [49, 130]. Using semi-empirical modeling approaches, the study found that barrier height, freeway width, and atmospheric turbulence were key factors determining pollutant dispersion. Results from Schulte et al. are consistent with the studies above that look specifically at varying barrier heights and atmospheric stability [130].

Appropriate context & other considerations

Research shows that solid barriers can be effective at reducing near-roadway pollution concentrations, but many other considerations should be taken into account before deciding to implement these as a means to reduce near-roadway pollution exposure. Local planners should consider consulting with highway experts at FHWA or Caltrans and referencing some of the many resources that are available to assist with the selection, planning, and design of solid barriers, including (but not limited to) the following:

- FHWA Highway Noise Barrier Design Handbook: *http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/index.cfm*
- FHWA Guide to Visual Quality in Noise Barrier Design *http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/visql/index.cfm*
- FHWA Brochure, "Keeping the Noise Down: Highway Traffic Noise Barriers" *http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/keepdown.pdf*
- Caltrans Highway Design Manual, Chapter 1100 Highway Traffic Noise Abatement *http://www.dot.ca.gov/hq/oppd/hdm/pdf/english/chp1100.pdf*
- Caltrans Project Development Procedures Manual, Chapter 30 Highway Traffic Noise Abatement: *http://www.dot.ca.gov/hq/oppd/pdpm/chap_pdf/chapt30.pdf*

Solid barriers are only appropriate for installation along freeways. When implemented in non-freeway settings, solid barriers can increase vehicle miles traveled, disrupt community connectivity, and counteract planners' efforts to encourage walking, biking, and complete streets designs.

Research shows that there are design features of solid barriers that should be avoided in order to maximize their effectiveness in reducing pollutant concentrations near high-volume roadways. For example, gaps and edges are places where pollutants can concentrate and creep around barriers, so gaps should be avoided and edges should occur where sensitive uses will not be exposed to elevated pollution levels [50].

Some studies indicate that barriers may result in increased on-road pollution concentrations, as was discussed previously under "*Important overarching considerations in selecting strategies*" that users of this Technical Advisory should take into account. This is not observed in all cases, but it is worth considering whether or not the site-specific conditions will result in very high on-road concentrations and additional exposure reduction strategies that could be implemented in concert to reduce them. Possibilities include other strategies that would reduce roadway volumes and thereby bring down the emissions rates of the roadway segment where a barrier may be implemented.

Before implementing solid barriers, planners should inform nearby residents and the public to ensure that the community is involved in the proposal and planning of the barrier before it is implemented. FHWA finds that people's reactions to noise barriers can be mixed. In the past, residents that live near roadways reported that solid barriers make conversations and sleeping easier in their homes and that, as a result of the barrier, they are more likely to open windows and spend time outdoors. Others have complained that solid barriers restrict views, contribute to a sense of confinement, reduce circulation, and can create an eyesore if the barrier is not maintained or designed with aesthetics in mind. Additionally, if solid barriers disrupt existing network connectivity, they could also result in an increase in vehicle miles traveled [131]. Planners should also consult with their local air quality management district to see if it provides additional recommendations for this type of strategy.

In addition to mitigating pollution exposure, solid barriers benefit near-roadway populations by reducing noise from roadways or freeways. Several studies have shown an association between roadway noise to a variety of physical and psychological health outcomes. Because noise can cause stress in humans, it may be linked to a variety of stress-related diseases, including hypertension, anxiety, and heart disease [132]. The negative health outcomes of stress are particularly serious if noise causes disruption in sleep cycles [133]. One survey of residents near a sound wall found that most felt that sleeping conditions were improved after the barrier was built [134]. Solid barriers and sound walls can reduce the loudness of traffic noise by as much as 50 percent [135].

6: Vegetation for pollutant dispersion

FINDING: Studies indicate that vegetation has the potential to alter pollutant transport and dispersion. In some studies, specific locations and conditions translated to air quality benefits (e.g., pollution concentrations of up to 20 percent on the leeward side of the tree line). It should be noted that most studies were conducted on the East Coast and in Europe where vegetation types and densities differ from what is found in California.

APPROPRIATE CONTEXT & OTHER CONSIDERATIONS: Online tools are available to assist with the selection of appropriate vegetation considering allergen impacts, watering needs, and other factors. Maximum benefits have been shown to occur when vegetation is combined with solid barriers.

Vegetation, including plants and trees, has been studied as a means of improving air quality by assisting in the dispersion of near-roadway pollution. Jeanjean et al. [136] modeled the effectiveness of trees at dispersing road traffic emissions and found that they can reduce ambient pollutant concentrations by increasing turbulence. Other studies have included the effect of urban parks and green belts. Experimental studies measured reductions of PM (and gases) attributable to urban parks and forests by measuring within, near and away from urban parks, finding reduced levels of PM and other pollutants (NO_2, SO_2) within and near park areas [137, 138]. Similarly, strategies such as creating green belts have been used as an environmental management strategy and appear to be successful in reducing air pollution [139, 140].

An emerging area of study examines the potential air quality impact of vegetation as a barrier and vegetation combined with solid barriers. Brantley et al. found that black carbon on the leeward side of the tree line was reduced up to 22 percent compared to the BC levels measured on the traffic adjacent side of the tree line, indicating that trees may provide some air quality improvement [141]. Baldauf et al. conducted a field study at a site in Raleigh, North Carolina that provided an opportunity to evaluate near-road air quality with no barriers, with a noise barrier only, and with a noise barrier and vegetation adjacent to the road. The study results suggested that the presence of mature trees (~10 m tall) in addition to the barrier lowered PM number concentrations beyond what was observed in the barrier-only scenario. Researchers attributed this additional reduction to increased turbulence and mixing created by the presence of the trees [48]. However, a subsequent study by Hagler et al. showed mixed results for vegetative barriers. UFP concentrations were sometimes higher and sometimes lower at the two vegetative barrier sites, which were characterized by relatively thin tree stands, one evergreen, and one deciduous (all sites were in central North Carolina). The researchers posit that study and site-specific conditions may have influenced these results, including the relative sparseness of the tree stands that acted as vegetative barriers [124].

Modeling studies also support the air quality improvement potential of vegetative barriers [128, 142, 143]. Fuller et al. [143] modeled a vegetation screen separating a freeway in Davis, California from a nearby elementary school. The modeling showed that—with the tree configurations studied—74 percent of PM impacted a tree surface. This means that the particles did not merely pass by the tree, but rather impacted and may have deposited on the tree itself. The modeling study also found that installing multiple rows of trees maximized the potential for impaction. The most recent modeling study, by Tong et al., found that the greatest reduction in downwind particle concentration was associated with a vegetation-solid barrier combination, whereby trees are planted next to a solid barrier [144]. However, the modeling for this configuration also showed significant increases in on-road particle concentrations.

A recent study has also investigated the effect of tree stands on indoor PM levels. While being indoors provides some protection from pollution exposure, Maher et al. [145] found that trees planted outside the home can provide substantial reductions in PM inside the home (>50 percent reduction).

It is worth noting that these measurement studies take advantage of existing tree stands or vegetative barriers with various densities, plant species, leaf shapes, and other variables, and it is difficult to isolate the variables that most strongly contribute to potential air quality improvement. In addition, these studies have been mostly conducted in the U.K. or on the east coast of the U.S., and the greatest effectiveness has been observed with extremely dense vegetative stands that provide a solid barrier (with no gaps, from ground-level to top of the canopy) between roadways and people that live or spend time in near roadway environments.

A recent ARB-funded study examined vegetation in combination with solid barriers in California. At the time of the writing of this Technical Advisory, the final report on the study was not yet available, but upon finalization, it will be published at the associated ARB Research webpage.[26] Measurements from the study show that the combination of vegetation (trees) and soundwalls is associated with a reduction in BC, UFP, PM2.5, and NO_x concentrations, when ideal or perpendicular wind conditions are present. The concentration reductions vary from 4.8 percent to 28 percent, depending on the location and wind conditions. The study looked at many wind conditions outside of the simple perpendicular wind pattern and found that the soundwall/tree combination barrier may have little or no effect in very high wind cases and in parallel wind cases. A useful table summarizing conditions and measured values will appear in the final report. Additionally, the research project included the development of a model to estimate the reduction in pollution concentrations for combined soundwall and vegetation barriers. This model will also be made publicly available when this project is finalized later in 2017.

Appropriate context & other considerations

While much research is still underway to assess the effectiveness of vegetative barriers and solid barriers plus vegetation as a means for reducing near-roadway pollution concentrations, the U.S. EPA has synthesized research to date into a recent publication, "Recommendations for Constructing Roadside Vegetation Barriers to Improve Near-Road Air Quality."[27] The document summarizes research findings on the best practices for building roadside vegetative barriers to improve air quality, and includes examples of effective and ineffective vegetative barrier designs and also discussions of vegetation characteristics and how these may affect exposure reduction potential. Specifically, the document emphasizes that higher and thicker vegetation results in the greatest downwind pollution reduction. Research has shown that pollutants can meander around edges and through gaps, so vegetation should be densely planted and well-maintained to prevent gaps created by dead or dying trees. Figure 6, from U.S. EPA's publication provides examples of (a) effective barriers that have full coverage from ground to top of canopy and (b) ineffective vegetation barriers that may result in increased pollutant concentrations because of gaps and edge effects.

26 *https://www.arb.ca.gov/research/single-project.php?row_id=65195*

27 *https://www.epa.gov/air-research/recommendations-constructing-roadside-vegetation-barriers-improve-near-road-air-quality*.

Figure 6: Examples of effective and ineffective vegetative barriers. Image: U.S. EPA 2016.

This document also highlights a variety of non-air quality related considerations that should be weighed when considering planting trees or vegetation to mitigate pollution near high-volumes roadways. One important consideration is what to install and where to install it order to minimize potential negative impacts, including allergen production, water need, cost, and safety hazards. The overarching best management practice for urban forestry is to plant a diversity of species in accordance with the 30/20/10 rule: no more than 30 percent of trees should be species within the same family, no more than 20 percent should be from the same genus, and no more than 10 percent should be the same species. Diversity not only reduces concentrations of allergens, but also protects against pests, invasive species, climate change, and severe weather.

In February 2017, the Sacramento Metropolitan Air Quality Management District released a draft document, "Landscaping Guidance for Improving Air Quality near Roadways."[28] The document translates findings and recommendations from the above mentioned U.S. EPA document so that they can be applied in the unique conditions and circumstances found in the Sacramento region.

For tree installations, CAL FIRE and the USDA Forest Service have funded the Urban Forest Ecosystems Institute website, which includes a tree selection software tool called Selectree.[29] This online tool allows users to search for low allergen and drought resistant trees and to select for other characteristics that best fit the context of where they will be planted. To avoid over- or under-watering trees, "Save Our Water and Our Trees" guidance can be consulted.[30] Planners should also consult with their local air quality management district to see if it provides additional recommendations for this type of strategy.

As stated in the research summary above, wind conditions—including wind speed and direction—influence the effect of adding vegetation to a solid barrier. The local meteorological conditions displayed in a wind rose can help planners decide how much of an air quality benefit can be realized from the addition of trees to a soundwall. Some communities prefer to plant low growing vegetation near soundwalls or near freeways out of concerns for pedestrian safety, to reduce shelter for vermin, and to discourage illegal camping.

A potential co-benefit is the possibility that this action may help to mitigate the urban heat island effect.[31] If trees or vegetation replace or are installed over non-reflective, heat-absorbing surfaces, they can reflect light that may have otherwise been converted into heat. This reduction in heat can have important air quality and energy use benefits, since it may translate to reductions in the use of electricity for air conditioning. Additionally, trees and vegetation can encourage outdoor activity, walking and other non-vehicle modes, and improve the street aesthetic.

While trees and vegetation can increase pollutant dispersion and thereby improve air quality, some studies show that they can increase street-level pollutant levels under certain circumstances. The effectiveness of trees in mitigating pollution in urban street canyons depends on three major factors: (1) ventilation, (2) tree planting density/size of canopy, and (3) street width to building height ratio. In street canyons, roadside vegetation may lead to increased pollutant levels in the street canyon at the street level, as the presence of trees can reduce ventilation, effectively trapping pollutants in the canyon; this aerodynamic effect has been shown to be much stronger than the pollutant removal from trees [146]. Increasing tree planting density reduces the effect of ventilation and can result in increased pollutant concentrations under the tree canopy [117, 147-149]. Larger tree crowns were associated with increasing concentrations [150]. However, increased ventilation can mitigate these effects [117, 149]. In addition to ventilation, the ratio of building height to street width (h/w) also is an important variable in describing the effect of trees in an urban canyon. Large h/w ratios reduce the trapping effect of trees by increasing ventilation in the local area [147, 149]. Finally, some tree species may contribute to the worsening of air quality by producing VOCs that can lead to ozone formation [151]. These species should be avoided, and online tools and expert consultations are helpful resources for planners as they choose tree species for installation.

28 *http://www.airquality.org/Residents/CEQA-Land-Use-Planning/Roadway-Protocol*

29 *http://ufei.calpoly.edu/index.lasso*

30 *http://saveourwater.com/what-you-can-do/tips/landscaping/save-our-water-and-our-trees/*

31 Urban air temperature is elevated compared to rural areas because of the prevalence of roofs and pavements that absorb heat and radiate it back into the ambient environment.

Strategies that remove pollution from the air

7: Indoor high efficiency filtration

FINDING: Studies show that particle filtration systems and devices, specifically high-efficiency filtration with mechanical ventilation or portable high efficiency air cleaners, can be highly effective for reducing indoor pollution concentrations. High efficiency filters in ventilation systems, for example, can remove 50-99 percent of particles in the air. However, research shows that filtration technologies for gaseous pollutants (VOCs) are variable in their effectiveness; some remove certain VOCs well, but not others.

APPROPRIATE CONTEXT & OTHER CONSIDERATIONS: Planners should be aware of current state and local building codes and their respective air filtration requirements, including requirements for amending code standards. Regular operation and maintenance is necessary for highest filter and ventilation efficiency, and is required by regulation in commercial buildings.

Reducing the entry of air pollutants into indoor environments from nearby roadways is critical for mitigating adverse health impacts. Research shows that both high efficiency filtration in central ventilation systems and portable air cleaners can effectively remove particles in most circumstances. Depending on particle size and other factors, central ventilation systems with high efficiency filtration remove about 50-99 percent and portable air cleaners remove about 30-90 percent of the particles in the air. Unlike particle filtration, filtration technologies for gaseous pollutants can be useful in some circumstances but generally are not as effective as particle filters.

Filter efficiency is rated using several scales, the most common of which is the minimum efficiency reporting value (MERV) rating system. A table illustrating the features and characteristics of MERV rated filters can be found in Appendix B. Flat, one-inch fiberglass filters are the most commonly used filters in residential heating and air systems. They remove only a portion of the largest particles in the airstream that passes through the filter and are typically rated no higher than MERV 4. MERV 5 to MERV 8 filters are medium efficiency filters that remove some additional types of particles such as mold spores and cat and dog dander, but they still do not remove the finer particles produced on roadways. MERV 9 to MERV 12 filters begin to remove particles in the smaller fraction of PM2.5. Higher efficiency MERV 13 to MERV 16 filters remove a portion of the ultrafine and submicron particles emitted from vehicles. True HEPA (high efficiency particulate arrestance) filters—equivalent to MERV 17 to MERV 20—remove 99.97 percent to 99.999 percent of particles less than 0.3 microns (μm). HEPA filters are available for use in residential applications, but they are not yet in widespread use in residences.

High efficiency filtration with mechanical ventilation

Mechanical ventilation integrated with in-duct filters removes some air pollutants when outdoor air passes through the filters and through deposition in the ducts. The amount of air pollutants removed depends on the air flow passing through the filters and the filtration efficiency of the filters. The performance of high efficiency filtration with mechanical ventilation has been evaluated by both field measurements and modeling simulations for residences, schools, and commercial buildings.

In residences, field studies of high efficiency filtration with mechanical ventilation have found that these systems can reduce air pollutants of outdoor origin by 50-98 percent [152-154]. In a seven-home study in northern California, Bhangar et al. [152] found that when filtration was active (systems turned on) at the two homes with active filtration in a mechanical system, the portion of indoor particles from outdoors was lower by 54 percent and 74 percent respectively, than when they were turned off (no filtration). In the most recent ARB-funded study in a test home, Singer et al. [154] measured indoor reductions of incoming outdoor PM2.5 particles up to 97-98 percent with MERV 16 filtration on a supply ventilation system and one central ventilation system configuration. MacIntosh et al. [155] measured particle removal rates of various in-duct filters that varied in thickness and found that, compared to a 1-inch filter, using a 5-inch MERV 8 filter increased the PM2.5 removal rates by 4.6 times. Stephens et al. [156] used four different methods to estimate the particle removal efficiencies of filters in the heating, ventilation, and air conditioning (HVAC) system of a test house, and found that all methods showed significantly higher removal efficiencies for MERV 11 filters than MERV 7 or lower filters across the size range (0.3-10 μm) measured, by about 20-50 percent. Modeling simulations show similar results. Brown et al. [157] found that, compared to a MERV 1 fiberglass filter, a MERV 12 or higher filter can effectively remove 63-76 percent more PM2.5 of outdoor origin. Using the same model as Brown et al., MacIntosh et al. [158] found an indoor/outdoor ratio of 0.1 for PM2.5 (a reduction of 90 percent) for homes with a high efficiency electrostatic air cleaner in the HVAC systems. This was significantly lower than the ratio of 0.35 (65 percent reduction) found in homes with a one-inch media filter and 0.57 (43 percent reduction) for homes with natural ventilation.

Although the MERV rating system does not specify removal efficiencies for particles smaller than 0.3 μm in diameter, a few studies have evaluated the performance of high efficiency filtration on UFPs. In a recent study of various filtration levels and types of mechanical ventilation in a test home, Singer et al. found good removal of UFP, including up to 99 percent removal of incoming UFP from the outdoors with a MERV 16 filter on either a supply ventilation system or a central system [154]. The researchers also measured air flow resistance for the highest MERV filters tested, and found that it was not an issue; a deep pleat MERV16 filter reduced airflow by just 2.7 percent and a 1-inch MERV13 filter reduced airflow by 4.9 percent. Stephens and Siegel [159] found that achieving substantial removal of UFPs in real residential environments (>50 percent removal efficiency) requires higher efficiency filters (e.g., MERV 13 or higher) than those typically used in homes. A field study in a radio station surrounded by busy roads in Australia showed that adding a MERV 7-8 equivalent pre-filter and a MERV 14-15 equivalent filter to the HVAC system increased overall removal efficiency for UFPs by 48 percent [160]. In a modeling study, Azimi et al. [161] used about 200 outdoor particle size distributions and the single-pass filter removal efficiencies obtained from the literature to estimate the removal efficiencies for UFPs of outdoor origin. This study found that, assuming an HVAC system operates with 100 percent outdoor air, the UFP removal efficiencies for MERV 16 or higher filters were over 98 percent, compared to 12 percent for MERV 7 or lower filters.

Similar findings on high efficiency filtration with mechanical ventilation were also reported in schools and other commercial buildings. In a study of a single school in Utah, indoor submicron particle counts were reduced to just one-eighth of the outdoor levels in a building with a mechanical system using a MERV 8 filter, indicating substantial protection of air filtration in the HVAC system against exposure to outdoor submicron particles [162]. In a pilot study in three southern California schools, a combination of MERV 16 filters used as a replacement for the normal panel filter in the ventilation system and in a separate filtration unit reduced indoor levels of outdoor-generated black carbon, UFPs and PM2.5 by 87-96 percent [163]. Use of the MERV 16 panel filter alone in the HVAC system achieved average particle reductions of nearly 90 percent. Wu et al. [164] found that in small and medium commercial buildings, indoor/outdoor ratios of black carbon were lower for those with MERV 6-8 filters in the HVAC systems, compared to the building with MERV 4 or lower filters, although the difference was not statistically significant. Zaatari et al. [165] estimated that the removal efficiencies of PM2.5 for the rooftop HVAC units in commercial buildings increased by 2.9-3.8 times after upgrading filters from MERV 8 to MERV 13-14.

High efficiency portable air cleaning devices

For homes and schools without forced air HVAC systems, portable or stand-alone air cleaning devices can be used to provide filtration. When portable air cleaners use high efficiency or HEPA filters and are appropriately sized for the space to be treated, they can typically achieve 30-60 percent removal of particles and sometimes up to 90 percent removal [166-169]. In the pilot study conducted in three southern California schools (discussed above), a large stand-alone air cleaner with MERV 16 filters reduced black carbon, UFP and PM2.5 by 90 percent or more, and PM2.5 mass by 75 percent, when the HVAC system was not running [163]. However, portable air cleaning devices are generally not as capable as in-duct air cleaners and those associated with mechanical ventilation systems for cleaning large areas. The review by Sublett [170] indicated that portable air cleaners with HEPA filters can lower particle levels indoors, but their effectiveness is limited to a single room and not the entire dwelling. The results from the field study by MacIntosh et al. [155] showed that five portable HEPA air cleaners operating at the same time were needed to achieve the same PM2.5 removal rate of an in-duct MERV 8 filter in a test house.

Appropriate context & other considerations

There are several California state building codes that relate to indoor air filtration in residences and commercial buildings, including offices. For workplaces, State regulation (California Labor Code, Title 8, Section 5142) requires that mechanical ventilation systems be operated as designed to provide the required amounts of outdoor air exchange during occupied periods. This includes properly servicing and maintaining filtration equipment. For residences, California building codes [2016 California Energy Code, Section 150.0 (m)(12)(B)] require mechanical ventilation in new construction; however, the current building code only requires a minimum filtration efficiency of MERV 6, which is rated lower than what is likely needed to adequately protect residents' health when homes are located near roadways. Local jurisdictions and planners should consider opportunities to revise local codes to include recommendations that filtration with a higher efficiency rating be installed when new housing is planned near roadways. Installation at the time of construction involves minimal incremental costs (equal to a two-inch or larger filter slot vs. the typical one-inch slot) and costs less than retrofitting existing buildings. Airflow resistance issues can be avoided by using deeper pleat filters, and there are high efficiency filters on the market that do not produce airflow resistance issues. This is true for retrofitting existing buildings as well, although costs may be higher depending on the nature and extent of the retrofit. The 2016 California Energy Code [Section 150.0 (m)(12)(C)] also requires mechanical systems, including heating and air conditioning systems, to be designed to accommodate the system's air filter media rated pressure drop for the system design airflow rate. Planners should also consult with their local air quality management district to see if it provides additional recommendations for this type of strategy.

Stand-alone air cleaners are less relevant for new homes which are now required to include mechanical ventilation, but good quality high-efficiency portable models can be useful in reducing indoor exposure to pollutants in existing homes that do not have mechanical ventilation. Also, they can be useful in homes that use bathroom exhaust type mechanical ventilation systems, which by their design cannot incorporate filtration of the incoming air because the supply air enters through leakage points throughout the building.

In general, particles are typically of greatest concern and pose the highest health risk, so HEPA filtration is likely to provide the highest degree of public health protection in near-roadway buildings. However, when VOC levels are of concern for a specific site, planners should consider additional options and consult with filtration experts. As described in more detail in Appendix A, adsorption using activated charcoal, sometimes with a catalyst such as potassium permanganate, is most commonly used, and while its effectiveness varies, it generally reduces VOCs, including VOCs commonly emitted from vehicles such as benzene and xylenes. Other methods may effectively reduce gaseous pollutants, but they also present the possibility of producing harmful byproducts. These technologies should be used with caution and in consultation with indoor air quality and filtration experts. Those seeking information on air cleaning devices can also consult the ARB document, "Air Cleaning Devices for the Home: Frequently Asked Questions."[32] The document discusses situations where an air cleaning device can help improve indoor air quality describes central system filtration and portable air cleaning technologies and the benefits of each.

Indoor high efficiency filtration is linked to a number of co-benefits. First, filtration can help reduce the dust and soot that collects in building interiors, making it easier to maintain a clean and hygienic environment. Additionally, some studies have shown improved employee health and reduced absences with reduced exposure to pollution. Indoor filtration is among a very small number of exposure reduction strategies that can be implemented in existing buildings.

32 *https://www.arb.ca.gov/research/indoor/acdsumm.pdf*

III. Conclusions

The implementation of SB 375 and other long-range land use and transportation planning efforts are important for California to meet its greenhouse gas emission reduction goals, to reduce pollution, to protect natural and working lands, and to promote equity and environmental justice. Many of these efforts focus on increasing development density as a means to reduce the frequency and length of automobile trips. In addition, greater density facilitates alternative modes of transportation, including transit, biking, and walking.

In some parts of the state, efforts to increase development density may result in infill development located near high-traffic roadways. The people that spend time in and around buildings located on these infill parcels will likely experience heightened exposures to traffic emissions, even as the vehicle fleet gets cleaner over time. Decades of research show an association between exposure to traffic emissions and serious health impacts, including cardiovascular and respiratory impacts. For new development, setbacks and buffers separating roadways from housing, offices, and other uses have been the primary defense against traffic emissions exposure and its public health impacts. This is largely because the distance-decay gradients for traffic-related pollutants is well studied and understood, and setbacks and buffers are effective ways to protect against the public health impacts of traffic pollution. However, given the significant population already living near high-volume roadways, and with the growing need to develop infill parcels to meet other state goals, ARB has funded and examined research that assesses other ways to reduce pollution exposure in near-roadway developments.

As this document shows, there are a variety of scientifically supported strategies to reduce near-roadway pollution exposure. Not only are these strategies well-studied and consistently effective, but they also fall into diverse categories. Urban design characteristics, roadside features, street design and traffic management strategies, and pollutant removal technologies outlined in this document give local planners and decision-makers options and thus the opportunity to find a strategy that best fits the local context.

As emphasized throughout this document, however, it is important that planners and decision-makers consider a variety of variables and tradeoffs when deciding which exposure reduction strategies make the most sense. Important points for consideration include (but are not limited to) the following:

- Site specific factors and conditions;
- Potential co-benefits, drawbacks, and direct and indirect effects;
- Interaction of the exposure reduction strategy with other local, regional, and state goals and policies;
- Community well-being and concerns, including safety and equity;
- Long-term effects of implementing strategies;
- Importance of implementing strategies in concert to enhance their effectiveness; and
- Other policies may need to be implemented concurrently to counter any potential drawbacks of the near-roadway strategy.

Many resources are available to assist local governments and other stakeholders to help them determine which exposure reduction strategies are appropriate for their community, including documents and guidance mentioned throughout this report. Various public and nongovernmental agencies may also be able to provide expert assistance, including ARB, Caltrans, the Office of Planning and Research, CA Department of Housing and Community Development, CAL FIRE, CA Department of Public Health, FHWA, U.S. EPA, MPOs, regional air districts, and local community groups.

Finally, many studies exploring this topic are currently underway and more will be published in the years to come. ARB will continue to review and analyze this research on a periodic basis. Updates to this document will be posted to ARB's website at: *https://www.arb.ca.gov/ch/landuse.htm*.

Appendix A: Strategies not meeting ARB's criteria at this time

This appendix contains a summary of findings for other potential exposure reduction strategies that ARB evaluated in its review of scientific, peer-reviewed literature. The following are not included in the main section of this document because they did not meet all of the following criteria at the time of the 2016 literature review.

1. Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations or emissions rates or for improving air flow to disperse pollutants.
2. Significant evidence of effective emissions reductions is documented in the scientific literature.
3. Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method of investigation).

The table that precedes each strategy indicates the criteria that were (þ) and were not (o) met.

Strategies that reduce traffic emissions

Onboard traffic signal system

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☑	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☐	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

To reduce the stop-and-go activities at intersections, in-vehicle signal systems that help drivers anticipate signals and speed limit have been introduced. One in-vehicle advanced driving alert system (ADAS) which provides real time information on traffic signal status to help drivers avoid hard braking at intersections was investigated for its potential to change drivers' behavior and reduce vehicle emissions [171]. A modeling simulation shows that ADAS can help reduce vehicle fuel consumption and CO_2 emissions both by 26-40 percent in a single vehicle in the tested hypothetical conditions. Another in-vehicle signal system which had been studied for its effect on traffic emissions is Intelligent Speed Adaptation (ISA) system [172]. ISA consists of a GPS navigation system that locates a vehicle on a digital map with speed limits for each street, and a device that can control fuel supply. It provides speed limit warnings and can cap the maximum driving speed automatically to comply with speed limits. This study found that with an ISA on board, there was a significant reduction in averge speed, but no statistically significant change in NO_X and PM emissions, and even a small increase in volatile organic compound (VOC) emissions.

Road pricing

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☑	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

For a few decades, road pricing has been considered to be an effective way to manage traffic demand and generate revenue. In 1975, Singapore implemented the world's first congestion pricing scheme and since then, pricing schemes have been adopted in many cities worldwide. Road pricing programs, including the London Congestion Charging Scheme (CCS) and the Stockholm Congestion Tax Scheme, have been studied for their roles in reducing vehicular emissions.

Implemented in February 2003, the London Congestion Charging Scheme (CCS) assesses a single charge for vehicles entering a central London zone between 07:00–18:30 on weekdays, with several vehicle types exempt from the charge. Since the program's inception, vehicle kilometers travelled within the zone reduced by 15 percent and the average speed increased by 20 percent. Based on the measurements from a single roadside monitor within the CCS Zone, roadside levels of NO_x and NO dropped by 5 percent and 9.5 percent, respectively, but concentrations of NO_2 and PM10 increased by 2.1 percent and 5.6 percent, respectively [173]. Interestingly, similar changes were observed during the same hours during weekends when the scheme was not operating. This may be due to the exceptional meteorological conditions of 2003, when concentrations of PM10, NO_2 and O_3 were higher than those in 2002, perhaps causing the impacts of the implementation of the CCS zone to be concealed. In an attempt to understand the role meteorology might have played in the observations, a modeling simulation was conducted and found that total NO_x and PM10 emissions in the CCS zone were reduced by 12.0 percent and 11.9 percent, respectively [174]. Furthermore, Tonne et al. [175] conducted more extensive air pollution concentration modeling combining exposure-response relationships from the literature to predict the life expectancy impact of the CCS. This study estimated that 183 years of life per 100,000 people would be gained within the CCS zone.

The Stockholm Congestion Tax Scheme was employed between January 3 and July 31, 2006. Vehicles travelling into and out of the affected area were charged for every passage during weekdays. Based on measured and modelled changes in road traffic, this scheme resulted in a 15 percent reduction in total road use within the affected area. Total traffic emissions of NO_x and PM10 in this area fell by 8.5 and 13 percent, respectively [176]. It was estimated that with a permanent congestion tax system, the annual average NO_x concentrations would drop up to 12 percent and PM10 concentrations would drop up to 7 percent along the most densely trafficked streets.

Low emission zones

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☐	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

Low Emission Zones (LEZ) vary in terms of their parameters, but usually involve limiting vehicles into part or all of an urban area. Generally, there are three types of LEZs. An air quality based LEZ triggers action when air quality in the LEZ exceeds or is predicted to exceed a certain threshold. A technology based LEZ restricts certain vehicle types (i.e., vehicles that do not meet certain emission standards) from entering the designated zone. A transport-based LEZ usually aims to restrict, prioritize, and optimize traffic flow in order to reduce emissions.

A London-based study used empirical prediction models to evaluate the impacts of different LEZ scenarios on annual mean NO_2 concentrations in central London [177]. By reducing all road traffic in central London by 10 percent or 20 percent, the concentrations of NO_2 were decreased by 1.4-3.4 percent or 2.9-7.1 percent, respectively. Removing all pre-Euro I cars and light-goods vehicles reduced NO_2 level in London by 1.8-5.2 percent. Further removing all pre-Euro III heavy-goods vehicles and buses reduced NO_2 by 3.6-11.1 percent. A similar regulation implemented in Amsterdam excluded Euro 0, I and II heavy-duty vehicles from entering Amsterdam's Low Emission Zone (LEZA). Data from two monitoring sites within the LEZA showed that the traffic-contributed concentrations decreased by 4.9 percent for NO_2, 5.9 percent for NO_X, 5.8 percent for PM10, 7.7 percent for absorbance, and 12.9 percent for elemental carbon (EC) [178]. Boogaard et al. [179] investigated air pollution at street level before and after implementation of LEZ in the inner-city of five Dutch cities. The Dutch LEZ restricts old heavy-duty vehicles entering the LEZ, including all Euro-0, I, II trucks and Euro-III trucks if older than 8 years or not retrofitted with particle filters. The results showed that the traffic-related pollutants monitored, including 'soot', NO_X, and elemental composition (Cr, Cu, Fe), did not decrease significantly. Only PM2.5 reductions, which fell 30 percent, were large compared to the observed reductions at the corresponding suburban control location (22 percent). While overall, the Dutch study did not find reductions in soot, NO_X, and NO_2, in one urban street where traffic intensity was reduced 50 percent, they were found to be reduced by 41, 36, and 25 percent, respectively, compared to reductions at the suburban control location (22, 14, and 7 percent, respectively). Acero et al. [180] studied the emission reductions related to a minor extension of a pre-existing LEZ. This LEZ is around 0.1 kilometer^2 with 60 percent of the area occupied by buildings. Only resident and commercial vehicles can operate within this LEZ during certain hours. The modeling simulation showed that if the LEZ is extended to include a 170 meter street during weekend, there will be a reduction of 6.4 percent for PM10 and 6.6 percent for NO_2 within the LEZ. But the impact outside the LEZ was negligible.

An extreme case of LEZ is called a pedestrianization scheme, which forbids any vehicles entering a small region, usually a commercial or residential area. Chiquetto [181] analyzed the influence of a pedestrianization scheme in Chester, UK on total vehicle exhaust emissions, local levels of air pollution concentration, and noise from traffic. The results showed that the pedestrianization scheme reduced air pollution in the pedestrian area 70-80 percent. However, the subsequent re-routing of traffic increased average air pollutant concentrations in the city as a whole by 6 percent.

Road surface designs

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☑	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☐	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

Special road surface designs, including speed humps and bumps, pavement treatments, chicanes, and raised crosswalks and speed tables have been used for decades to reduce driving speed and improve pedestrian safety. Most drivers will slow down when driving over these structures, which results in a series of accelerations and decelerations, and are anticipated to have adverse impact on vehicle emissions. A few studies have investigated the impacts of some road surface designs on emissions from vehicles driving on roadways. A case study in Gothenburg, Sweden used a simulation model to investigate the environmental impacts of speed humps for different traffic intensities and driving speed limits and found that speed humps increased fuel consumption estimates by 3-19 percent. Accordingly, the introduction of speed bumps increased the emissions from a singular vehicle by 7-62 percent for HC, 0.4-32 percent for CO, and 5-26 percent for NO_X [182]. Similarly, Ahn and Rakha [53] simulated vehicle emissions using vehicle driving data and energy and emission modeling, and found the installation of speed humps and bumps increased fuel consumption by 53 percent, and the emissions of HC, CO, NO_X, and CO_2 by 51, 44, 110, and 52 percent, respectively.

Strategies that increase dispersion of traffic pollution

Taller buildings/pollution dispersion along vertical gradients

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☑	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

A handful of studies have examined how pollution concentrations change along a vertical gradient with increasing distance from ground-level. These studies help to shed light on exposure levels that may be experienced by people that spend prolonged periods of time above ground-level along street corridors (e.g., in offices, homes, etc.).

Morawska et al. [183] examined both horizontal and vertical pollutant concentration gradients near busy roadways in Brisbane, Australia (not an urban canyon site). The researchers found that fine and ultrafine particle concentrations outside buildings with 9 to 26 stories were not significant and can be highly variable, depending on other local sources and local meteorological conditions. Also, they found no correlation between particle concentration and height for buildings 15 meters or more from the freeway. For buildings in the immediate proximity of the roadway, pollutant concentrations throughout the building envelope were very high, comparable to those in the immediate vicinity of the road, indicating that undiluted concentrations drawn directly from the freeway encircled the buildings.

In contrast, several studies from urban areas in Asia show statistically significant reductions in pollutant concentrations with increasing distance from ground-level [184-186]. However, for some pollutants (e.g. polycyclic aromatic hydrocarbons, PAHs, and PM2.5), the attenuation rate slows above a certain threshold, indicating that concentrations drop off more sharply closer to pollution sources. In a study conducted in Macao, China, Wu et al. [184] found that the mass concentrations of PM10, PM2.5, and PM1 decreased by 40, 38, and 20 percent respectively at 79 meters (~26 floors) above ground level, and maximum mass concentrations were measured at 2 meters above the ground. Li et al. [185] studied changes in PM2.5 and PAH concentrations along a vertical gradient at a residential building adjacent to a busy roadway in Guangzhou, China. The study found that both pollutants decreased significantly at heights above ground level at an urban study site. At 24 meters (~8 stories), PM2.5 concentrations had decreased by 36 percent from the maximum, but the rate of decrease slowed at a height of 36 meters (~12 stories). PAH concentrations showed a similar vertical tapering off; at a height of 33 meters (~11 stories), PAH concentrations had fallen to 51 percent of the maximum. Tao et al. [186] confirmed these prior results via measurements collected along a meteorological tower in Beijing during the winter.

Recent studies in the U.S. agree with the directionality of these Asian studies but differ in the magnitude of the pollutant concentration reductions observed. Wu et al. [187] studied particle number concentration and particulate matter mass concentration by hoisting instruments up the vertical face of an 11-story (35 meter) building in Boston's Chinatown. The researchers found that particle number concentration decreased by 7.7 percent and PM2.5 concentration decreased 3.6 percent with increasing height from 0 to 35 meters. Another study in New York found that outdoor black carbon and polycyclic aromatic hydrocarbons were significantly reduced for floors 6 through 32 during the non-heating season only [188]. Researchers also measured the highest median concentrations for outdoor pollutants at floors 3 to 5, but this trend was not statistically significant and the elevated pollutants were believed to come from nearby rooftop exhausts.

Finally, in a modeling study, Zhou and Levy [189] found that—in a street canyon with a height of 60 meters and a width of 30 meters—approximately 30 percent of the ground-level concentrations of PM10, PM2.5, CO, and NO remains at the top of the street canyon. For NO_2, 50 percent of the ground-level concentration remains at the top of the street canyon. Overall, the sharpest decline in pollutant concentration occurred within 15 meters (~50 feet) of the ground.

While the research literature shows that transportation related pollutants may decline with increasing distance from the roadway along a vertical gradient, there are many other factors at play, including local meteorological conditions, seasonal differences, and other local pollution sources. Studies that observed higher concentrations several floors up attributed these to other pollution sources, like exhaust vents on adjacent buildings. Thus, while multi-story housing may reduce exposure in some situations, further research is needed to determine conditions under which tall buildings might provide a reliable approach to reduce exposure near busy roadways.

Air intake location

☑	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☐	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

Although locating air intakes for mechanical ventilation systems on the opposite side of the building from the nearby outdoor source and prevailing wind direction seems logical, there is little scientific evidence that this practice results in significant indoor air quality improvement, and the limited research indicates that many site-specific factors influence effectiveness. Specifically, the reduction of pollutant entry depends on the distance of the intake from the outdoor source, the consistency of the prevailing wind direction, and any local geographical or structural objects that might produce wind turbulence or eddies near the building and the air intake. It is likely that moving the air intake would be somewhat beneficial if the outdoor source is very near the intake and the intake is moved fairly far away. Otherwise, because particles tend to disperse quickly and particle plumes "flow" around buildings, elevated particle concentrations around the building will be fairly consistent. Also, according to the abovementioned Australian study, researchers found consistently high submicron particle concentrations enveloping a building located within 15 meters of the roadway [183]. Thus, while there may be some benefit to moving the intake in certain circumstances, that benefit likely will be very small, and is not reliable or quantifiable at this time.

Roadway elevation

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☐	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

Elevation of the road surface plays an important role in the transport and dispersion of traffic-emitted air pollutants in the near-road environment [190]. A wind tunnel study indicates that at-grade roadways experience the least amount of pollutant mixing if no other structures exist near the road, while depressed or elevated roadways result in higher pollutant mixing and dispersion, and therefore lower near-road concentrations of air pollutants [129]. Field measurements have also evaluated the impact of road grade on local air pollution, finding depressed configurations are associated with lower pollutant levels for downwind near-road environments. For instance, size-resolved PM samples collected upwind and downwind of five urban freeways in Los Angeles, CA with different road configurations (i.e., at-grade, sloped depressed section, and elevated fill section) indicated that depressed sections resulted in lower downwind concentration [191]. Similarly, a study in Santa Monica, CA investigated particulate dispersion from highways located along depressed sections, and found lower near-road pollutant concentrations compared with theoretical dispersion model predictions for at-grade roadways [192]. By monitoring PM2.5, NO_x, elemental carbon, and particle number concentration, one study in Antwerp, Belgium found that taking into account confounding parameters (i.e., time of day, day of the week, distance to the road and wind speed), the contribution of traffic to air pollutant concentrations in the near-roadway environment is significantly higher for a ground level motorway than a motorway flyover [193]. Similarly, a study by Nikolaou et al. [194] found that elevated freeways had slightly lower levels of near-road pollution while depressed freeways were similar to at-grade roads.

Sidewalk and bicycle lane placement

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☑	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

The separation of a pedestrian or cyclist from the roadway may be an effective mitigation measure for walkers and bikers, but not necessarily for people that dwell in buildings near-roadways.

Studies have shown that route choice (walking or biking on less trafficked roads) or location of a walkway or bike lane with respect to a busy roadway (at or below grade, roadside boundary wall or parked cars separating street from foot path) can significantly reduce exposure to air pollution [126, 195-198]. McNabola et al. [126] found that PM2.5 levels on a boardwalk 1-3 meters from the road were almost three times lower than PM2.5 levels on a sidewalk immediately adjacent to the road. Kendrick et al. [196] conducted a similar study in Seattle with bicycle lanes adjacent to the roadway or a few meters away, separated by parked cars. They found up to 40 percent reduction in UFP concentrations when the bicycle lane was further away from the road.

Proper route choice and time of commute can also reduce exposure. In Copenhagen, Hertel et al. [195] not only found that low trafficked routes were beneficial in terms of air pollutant exposure, travel during non-rush hour commutes also reduced exposures by 5-20 percent. In Australia, a study showed UFP concentrations that are two times higher on average on routes with high traffic [197]. Such studies suggest alternate routes and commute times may reduce exposure to traffic-related pollutants. Hatzopoulou et al. [198] developed a web-based planning tool to reduce such exposures for cyclists in Montreal and found that decreased exposure could be achieved with only a small increase in overall route length.

Truck rerouting

☐	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☑	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

Field measurements before and after local traffic rerouting interventions were in place agree that these interventions improve local air quality [199, 200]. After a by-pass was operational in North Wales, PM concentrations decreased between 23-29 percent in nearby residential streets as heavy-duty traffic decreased almost in half [200]. Similarly, opening of a tunnel in Australia led to a redistribution of NO_2 concentrations with the greatest decrease occurring along the bypassed main road [199]. Modeling studies have confirmed that rerouting traffic decreases localized air pollution [201, 202]. For example, rerouting trucks weighing over 5 tons away from residential streets in San Diego, CA is estimated to have decreased diesel particulate matter by 99 percent near residences and schools [201]. Truck restrictions in the Philippines were also shown to have decreased CO, NO_X, and PM in the zone closest to the restrictions [202]. Despite local improvements in air quality, regional emissions increased because trucks were required to drive longer distances [199-202]. Because air pollutant concentrations decline with distance as one moves away from heavily trafficked roads [17], the improvements from these local interventions are expected to be limited to about 500 feet from the intervention site. Therefore, these local traffic interventions could have a significant impact in areas with a high density of residences, schools, or hospitals nearby. However, results from a health questionnaire indicate that health improvements of residents were fairly modest after trucks were rerouted off the local streets through a by-pass [200].

A microscopic modeling study of freeway traffic emissions determined that hydrocarbon, CO, and NO_X emissions from heavy-duty vehicles during road-work congestion were highest followed by rush-hour congestion compared with periods of free-flowing traffic [203]. External parameters that impact CO_2 truck emissions include travel speed, road gradient, whether congestion is present, temperature, wind, and road surface [204].

Strategies that remove pollution from the air

Removal of gaseous pollutants by filtration

☐	Criterion 1	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☐	Criterion 2	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	Criterion 3	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

As pointed out in the review by Zhang et al. [205], mechanical filters can efficiently remove particles, but are not as effective for gaseous pollutants. Many technologies have been developed to address indoor air quality issues related to gaseous pollutants. One of the most common methods is adsorption whereby the pollutant is transferred from a gaseous phase to a solid phase, usually via activated carbon. Because a wide range of gaseous pollutants with different attractive forces to different sorbents are present indoors, and testing conditions such as temperature and relative humidity differed, the removal efficiencies of adsorption reported in the literature vary greatly. In the study by Batterman et al. [206], a portable air cleaner with an activated carbon pre-filter and a HEPA filter removed 30-70 percent of particles in cigarette smokers' houses, but did not change the concentration of volatile organic chemicals (VOCs). Chen et al. [207] tested the initial performance of 15 air cleaners with a mixture of 16 representative VOCs in a chamber study, and found that sorption filtration removed some but not all VOCs (light and very volatile gases such as aldehydes and dichloromethane were not well removed). However, devices that included sorption media such as activated alumina impregnated with potassium permanganate showed better VOC removal efficiencies. Using a modeling analysis, Sidheswaran et al. [208] estimated that the combination of using activated carbon fiber filters for air cleaning in HVAC systems and a 50 percent reduction in ventilation could decrease indoor concentrations of VOCs by 60-80 percent and reduce formaldehyde concentrations by 12-40 percent. In the southern California schools study discussed above, the stand-alone unit used in one of the schools included charcoal sorbent for removal of gaseous pollutants; it removed 52 percent of the benzene indoors and 15 percent of total VOCs when operated with the HVAC turned off [163]. In addition to activated carbon, various adsorbents for VOC removal had been studied, but their removal efficiencies under real world conditions were not conclusive [209-212].

Other available technologies for gaseous pollutant removal include photocatalytic oxidation (PCO), ozone-oxidation, non-thermal plasma, and other technologies. PCO systems combine ultraviolet rays with a catalyst, usually a titanium oxide-coated filter. This interaction produces highly reactive electrons that in turn combine with and break down VOCs and other pollutants in the air. Hodgson et al. [213] found that, when challenged with complex VOC mixtures, ultraviolet PCO systems achieved 20-80 percent VOC conversion efficiencies. However, due to incomplete mineralization of common VOCs, this device also produced formaldehyde, acetaldehyde, acetone, formic acid and acetic acid as by-products. The formation of secondary air pollutants was also reported in a recent ARB-funded study [214]. Ozone oxidation is generally not recommended as a means for removing gaseous pollutants in indoor environments because the oxidation process can produce other air pollutants like formaldehyde and UFPs, which also have serious adverse health impacts [215-217]. To protect Californians from adverse health effects related to ozone-emitting air cleaning devices, ARB adopted a regulation in September 2007 to limit the ozone emissions from indoor air cleaning devices to no more than 50 ppb.[33] Non-thermal plasma has been found to effectively remove VOCs in some laboratory studies. Quoc An et al. [218] reported that the toluene removal efficiencies were in the 55-60 percent range with non-thermal plasma only, and increased to 96 percent when combined with a catalyst. But removal efficiencies of

33 *https://www.arb.ca.gov/regs/regs-17.htm*

this technology were much lower under real world conditions, and like PCO, the process can also produce harmful byproducts, including aldehydes and ketones. The ARB-funded study discussed above [219] also tested a plasma generator. While the device removed 29 percent of VOCs from the chamber, small amounts of ozone and formaldehyde were emitted.

Overall, the literature shows highly variable removal efficiencies for gaseous pollutants, ranging from 0 to 80 percent. Some technologies have been found to generate harmful by-products during the removal process. Specifically, they either re-emit VOCs that have been removed over time, or emit potentially harmful reaction products from the process during which VOCs are removed. Thus, these VOC removal technologies are not always reliable, and caution should be taken when using these technologies for indoor environments.

Removal of air pollution via vegetation

☑	**Criterion 1**	Consistent findings from multiple studies support the strategy as a means for reducing pollution concentrations, etc.
☐	**Criterion 2**	Significant evidence of effective emissions reductions is documented in the scientific literature.
☑	**Criterion 3**	Diversity in the study methods supports consistent findings (such that strategies do not exclusively rely on one method).

The ability of plants to remove pollutants from the atmosphere depends on absorption and deposition onto vegetative material. The scientific literature contains both modeling and measurement studies that characterize this removal process. An early study indicated that vegetation could effectively absorb gaseous air pollutants including NO_2 and ozone [220]. Later studies have investigated the ability of trees to act as an effective particle sink. A review of the literature [221] and measurement studies [222] found that coniferous species had the greatest potential to capture particles compared to their deciduous counterparts, although the deposition of PM on surfaces by particle size varies with different plant species [223]. For UFPs, the capture efficiency of vegetation tends to decrease with increasing particle size, increasing wind speed, and decreasing packing density, which in wind tunnel studies is the volume fraction of the wind tunnel occupied by the branches [224].

Many studies have modeled the application and effectiveness of vegetation in urban areas to remove pollution by deposition [225-228]. These studies have shown that trees and other vegetation have the ability to remove pollutants from the atmosphere in urban contexts. Separate from such processes; however, some trees can also emit volatile organic compounds (VOCs) that can lead to the formation of ozone [151]. As such, some tree species may be more advantageous than others, in terms of air quality. In the United Kingdom one study suggests an index to rank trees in order of their potential to improve air quality using an atmospheric chemistry model [229]. In this study, researchers used species-specific VOCs emission rates, pollutant deposition rates, and tree cover data to develop an urban tree air quality score. Conifers and silver birch were found to have the highest potential to improve air quality while several deciduous tree species such as oak and poplar had the greatest potential to worsen air quality when planted in large numbers. These results are consistent with other studies discussed previously.

The application of trees and vegetation to remove air pollutants have been studied from a city-wide [230, 231] to microscale (e.g., street canyon) level [232, 233]. Although trees and vegetation have the potential to remove large quantities of air pollutants from ambient air, the process of pollutant removal through dry deposition alone can only improve air quality by a small fraction (<5 percent), particularly in urban areas [225-228, 231, 234, 235]. However, Pugh et al. [236] found that, in the street canyon microenvironment, pollutant removal through green walls and roofs reduced levels of NO_2 and PM by 40-60 percent, respectively. Another study by Baik et al. [232] used computational fluid dynamics (CFD) modeling to illustrate how greening cools surrounding air to strengthen air flow in a street canyon, thereby reducing pollutant concentrations. These two studies suggest vegetation in the form of green walls and roofs is an effective mitigation measure for reducing exposure to traffic-related pollutants in urban street canyons. However, it is important to note that pollutant removal effectiveness increases as dispersion decreases, so these two mitigation goals may be at odds with one another (e.g., green walls and roofs may be less effective if mitigation to improve pollutant dispersion has been successfully implemented).

Appendix B: Characteristics of MERV-Rated Filters

MERV rating	Removal rate according to average particle size			Typical controlled contaminant or material sources (ASHRAE 52.2)	Typical building applications
	0.3-1.0	1.0-3.0	3.0-10.0		
1-4	—	—	< 20%	> 10 µm textile fibers, dust mites dust, pollen	Window AC units, common residential, minimal filtration
5	—	—	20-35%	3.0-10.0 µm cement dust, mold spores, dusting aids	Industrial workplace, better residential, commercial
8	—	—	> 70%		
9	—	< 50%	> 85%	1.0-3.0 µm legionella, some auto emissions, humidifier dust	Hospital laboratories, better commercial, superior residential
12	—	> 80%	> 90%		
13	< 75%	> 90%	> 90%	0.3 to 1.0 µm bacteria, droplet nuclei (sneeze), most tobacco smoke, insecticide dust	Superior commercial, smoking lounge, hospital care, general surgery
16	> 95%	> 95%	> 95%		
17**	> 99.97%			<0.3 µm (HEPA/ULPA filters)**, viruses, carbon dust, fine combustion smoke	Clean rooms, carcinogenic & radioactive materials, orthopedic surgery
18**	> 99.99%				
19, 20**	> 99.999%				

* Adapted from EPA 2009; originally from ANSI/ASHRAE Standard 52.2-2007.
** Not part of the official ASHRAE Standard 52.2 test, but added by ASHRAE for comparison purposes.

Acronyms

ARB	Air Resources Board
APCD	Air Pollution Control District
AQMD	Air Quality Management District
BAAQMD	Bay Area Air Quality Management District
BC	black carbon
CCS	Congestion Charging Scheme
CFD	computational fluid dynamics
CO	carbon monoxide
CO_2	carbon dioxide
DPM	diesel particulate matter
EC	elemental carbon
FHWA	Federal Highway Administration
GHG	greenhouse gas
HC	hydrocarbon
HDV	heavy-duty vehicle
HEPA	high-efficiency particulate arrestance
HVAC	heating, ventilation, and air conditioning
ICE	Intersection Control Evaluation
ICEV	internal combustion engine vehicle
I/O	ratio of in-cabin to on-roadway pollution concentrations
kph	kilometers per hour
LDV	light-duty vehicle
LEZ	low emission zone
MERV	minimum efficiency reporting value
mph	miles per hour
MPO	metropolitan planning organization
MUTCD	California Manual of Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NO_X	mono-nitrogen oxides (NO and NO_2)
OEHHA	Office of Environmental Health Hazard Assessment
PAH	polycyclic aromatic hydrocarbon
PCO	photocatalytic oxidation
PHEV	plug-in electric hybrid vehicle

PM10	particulate matter with an aerodynamic diameter of 10 micrometers or less
PM2.5	particulate matter with an aerodynamic diameter of 2.5 micrometers or less
ppb	parts per billion
ppm	parts per million
RTP	regional transportation plan
SB 375	Senate Bill 375
SCS	Sustainable Communities Strategy
TAC	toxic air contaminants
UFP	ultrafine particulate matter with an aerodynamic diameter of 0.1 micrometers or less
U.S. EPA	United States Environmental Protection Agency
VMT	vehicle miles traveled
VOC	volatile organic compound
ZEV	zero emission vehicle

References

1. Smith, K.R., et al., Walkability and body mass index: density, design, and new diversity measures. American Journal of Preventive Medicine, 2008. 35(3): p. 237-244.
2. Bertraud, A. and H.W. Richardson, Transit and density: Atlanta, the United States and western Europe. Urban Sprawl in Western Europe and the United States. London: Ashgate, 2004: p. 293-310.
3. Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO_2 Emissions. Special Report 298. 2009, Transportation Research Board: Washington, D.C.
4. Shu, S., et al., Air quality impacts of a CicLAvia event in Downtown Los Angeles, CA. Environmental Pollution, 2016. 208: p. 170-176.
5. Anzilotti, E. Paris Introduces Car-Free Sundays. The Atlantic: Citylab, 2016.
6. Houston, D., et al., Proximity of licensed child care facilities to near-roadway vehicle pollution. American Journal of Public Health, 2006. 96(9): p. 1611-1617.
7. Appatova, A.S., et al., Proximal exposure of public schools and students to major roadways: A nationwide US survey. Journal of Environmental Planning and Management, 2008. 51(5): p. 631-646.
8. Gunier, R.B., et al., Traffic density in California: socioeconomic and ethnic differences among potentially exposed children. Journal of Exposure Science and Environmental Epidemiology, 2003. 13(3): p. 240-246.
9. Houston, D., et al., Structural disparities of urban traffic in southern California: Implications for vehicle-related air pollution exposure in minority and high-poverty neighborhoods. Journal of Urban Affairs, 2004. 26(5): p. 565-592.
10. Archsmith, J., A. Kendall, and D. Rapson, From cradle to junkyard: assessing the life cycle greenhouse gas benefits of electric vehicles. Research in Transportation Economics, 2015. 52: p. 72-90.
11. Zhu, Y., et al., In-cabin commuter exposure to ultrafine particles on Los Angeles freeways. Environmental Science & Technology, 2007. 41(7): p. 2138-2145.
12. Propper, R., et al., Ambient and emission trends of toxic air contaminants in California. Environmental Science & Technology, 2015.
13. Zhu, Y., et al., Study of ultrafine particles near a major highway with heavy-duty diesel traffic. Atmospheric Environment, 2002a. 36(27): p. 4323-4335.
14. Zhu, Y., et al., Concentration and size distribution of ultrafine particles near a major highway. Journal of the Air & Waste Management Association, 2002b. 52(9): p. 1032-1042.
15. Hitchins, J., et al., Concentrations of submicrometre particles from vehicle emissions near a major road. Atmospheric Environment, 2000. 34(1): p. 51-59.
16. Brunekreef, B., et al., Air pollution from truck traffic and lung function in children living near motorways. Epidemiology, 1997: p. 298-303.
17. Lin, S., et al., Childhood asthma hospitalization and residential exposure to state route traffic. Environmental Research, 2002. 88(2): p. 73-81.
18. Venn, A.J., et al., Living near a main road and the risk of wheezing illness in children. American Journal of Respiratory and Critical Care Medicine, 2001. 164(12): p. 2177-2180.
19. Kim, J.J., et al., Traffic-related air pollution near busy roads: the East Bay Children's Respiratory Health Study. American Journal of Respiratory and Critical Care Medicine, 2004. 170(5): p. 520-526.

20. Delfino, R.J., Epidemiologic evidence for asthma and exposure to air toxics: linkages between occupational, indoor, and community air pollution research. Environmental Health Perspectives, 2002. 110(Suppl 4): p. 573.
21. English, P., et al., Examining associations between childhood asthma and traffic flow using a geographic information system. Environmental Health Perspectives, 1999. 107(9): p. 761.
22. Caiazzo, F., et al., Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005. Atmospheric Environment, 2013. 79: p. 198-208.
23. Perez, L., et al., Near-roadway pollution and childhood asthma: implications for developing 'win-win' compact urban development and clean vehicle strategies. Environmental Health Perspectives: 2012. 120: p. 1619-1626.
24. Basu, R., et al., Effects of fine particulate matter and its constituents on low birth weight among full-term infants in California. Environmental Research, 2014. 128: p. 42-51.
25. Zhu, Y., et al., Comparison of daytime and nighttime concentration profiles and size distributions of ultrafine particles near a major highway. Environmental Science & Technology, 2006. 40(8): p. 2531-2536.
26. Choi, W., et al., Prevalence of wide area impacts downwind of freeways under pre-sunrise stable atmospheric conditions. Atmospheric Environment, 2012. 62: p. 318-327.
27. Durant, J., et al., Short-term variation in near-highway air pollutant gradients on a winter morning. Atmospheric Chemistry and Physics, 2010. 10: p. 8341-8352.
28. Huang, Y., X. Hu, and N. Zeng, Impact of wedge-shaped roofs on airflow and pollutant dispersion inside urban street canyons. Building and Environment, 2009. 44(12): p. 2335-2347.
29. Gordon, M., et al., Measured and modeled variation in pollutant concentration near roadways. Atmospheric Environment, 2012. 57: p. 138-145.
30. Zhu, Y., et al., Air pollutant concentrations near three Texas roadways, Part I: Ultrafine particles. Atmospheric Environment, 2009. 43(30): p. 4513-4522.
31. Hu, S., et al., A wide area of air pollutant impact downwind of a freeway during pre-sunrise hours. Atmospheric Environment, 2009. 43(16): p. 2541-2549.
32. Winer, A.M., et al., Investigation and Characterization of Air Pollution Concentrations and Gradients in Port-Adjacent Communities in West and Downtown Los Angeles Using a Mobile Platform, Final report to the Air Resources Board, Contract #14-348. 2010: University of California, Los Angeles.
33. Vance, C. and R. Hedel, The impact of urban form on automobile travel: disentangling causation from correlation. Transportation, 2007. 34(5): p. 575-588.
34. Ewing, R. and R. Cervero, Travel and the Built Environment: A Synthesis. Transportation Research Record: Journal of the Transportation Research Board, 2001. 1780: p. 87-114.
35. Cervero, R. and J. Murakami, Effects of built environments on vehicle miles traveled: evidence from 370 US urbanized areas. Environment and Planning A, 2010. 42(2): p. 400-418.
36. Holtzclaw, J., Using residential patterns and transit to decrease auto dependence and costs. Vol. 11. 1994: Natural Resources Defense Council, San Francisco, CA.
37. Holtzclaw, J., et al., Location Efficiency: Neighborhood and socio-economic characteristics determine auto ownership and use — Studies in Chicago, Los Angeles, and San Francisco. Transportation Planning and Technology, 2002. 25(1): p. 1-27.
38. Ewing, R., et al. Direct and Indirect Impacts of Light Rail Transit on VMT in Portland, OR: A Longitudinal Analysis. Transportation Research Board 93rd Annual Meeting. 2014.
39. McIntosh, J., et al., The role of urban form and transit in city car dependence: Analysis of 26 global cities from 1960 to 2000. Transportation Research Part D: Transport and Environment, 2014. 33: p. 95-110.
40. Friedman, M.S., et al., Impact of changes in transportation and commuting behaviors during the 1996 Summer Olympic Games in Atlanta on air quality and childhood asthma. Journal of the American Medical Association, 2001. 285(7): p. 897-905.
41. Denier van der Gon, H.A., et al., The policy relevance of wear emissions from road transport, now and in the future—an international workshop report and consensus statement. Journal of the Air & Waste Management Association, 2013. 63(2): p. 136-149.

42. Timmers, V.R. and P.A. Achten, Non-exhaust PM emissions from electric vehicles. Atmospheric Environment, 2016. 134: p. 10-17.
43. Notter, D.A., et al., Contribution of Li-ion batteries to the environmental impact of electric vehicles. Environmental Science & Technology, 2010. 44(17): p. 6550-6556.
44. Hawkins, T.R., et al., Comparative environmental life cycle assessment of conventional and electric vehicles. Journal of Industrial Ecology, 2013. 17(1): p. 53-64.
45. Hawkins, T.R., O.M. Gausen, and A.H. Strømman, Environmental impacts of hybrid and electric vehicles—a review. The International Journal of Life Cycle Assessment, 2012. 17(8): p. 997-1014.
46. Michalek, J.J., et al., Valuation of plug-in vehicle life-cycle air emissions and oil displacement benefits. Proceedings of the National Academy of Sciences, 2011. 108(40): p. 16554-16558.
47. Fruin, S., et al., Measurements and predictors of on-road ultrafine particle concentrations and associated pollutants in Los Angeles. Atmospheric Environment, 2008. 42(2): p. 207-219.
48. Baldauf, R., et al., Impacts of noise barriers on near-road air quality. Atmospheric Environment, 2008. 42(32): p. 7502-7507.
49. Schulte, N., and A. Venkatram, Effects of Sound Barriers on Dispersion from Roadways. 2013, Draft Final Report for the South Coast Air Quality Management District.
50. Hagler, G.S.W., et al., Model evaluation of roadside barrier impact on near-road air pollution. Atmospheric Environment, 2011. 45(15): p. 2522-2530.
51. Baldauf, R., et al., Influence of solid noise barriers on near-road and on-road air quality. Atmospheric Environment, 2016. 129: p. 265-276.
52. Xu, B. and Y. Zhu, Investigation on lowering commuters' in-cabin exposure to ultrafine particles. Transportation Research Part D: Transport and Environment, 2013. 18: p. 122-130.
53. Ahn, K. and H. Rakha, A field evaluation case study of the environmental and energy impacts of traffic calming. Transportation Research Part D: Transport and Environment, 2009. 14(6): p. 411-424.
54. Höglund, P.G., Alternative intersection design — a possible way of reducing air pollutant emissions from road and street traffic? Science of The Total Environment, 1994. 146–147: p. 35-44.
55. Várhelyi, A., The effects of small roundabouts on emissions and fuel consumption: a case study. Transportation Research Part D: Transport and Environment, 2002. 7(1): p. 65-71.
56. Mandavilli, S., M.J. Rys, and E.R. Russell, Environmental impact of modern roundabouts. International Journal of Industrial Ergonomics, 2008. 38(2): p. 135-142.
57. Ahn, K., N. Kronprasert, and H. Rakha, Energy and environmental assessment of high-speed roundabouts. Transportation Research Record: Journal of the Transportation Research Board, 2009(2123): p. 54-65.
58. Brown, M., TRL State of the Art Review--The Design of Roundabouts. 1995, London: HMSO.
59. Alphand, F., U. Noelle, and B. Guichet, Roundabouts and Road Safety: State of the Art in France, *Intersections without Traffic Signals II*. 1991, Springer-Verlag: Germany. p. 107-125.
60. Schoon, C. and J. Van Minnen, Accidents on Roundabouts: II. Second study into the road hazard presented by roundabouts, particularly with regard to cyclists and moped riders. SWOV Institute for Road Safety Research, Leidschendam, The Netherlands. Report R-93-16, 1993.
61. Coelho, M.C., T.L. Farias, and N.M. Rouphail, A methodology for modelling and measuring traffic and emission performance of speed control traffic signals. Atmospheric Environment, 2005. 39(13): p. 2367-2376.
62. Coelho, M.C., T.L. Farias, and N.M. Rouphail, Impact of speed control traffic signals on pollutant emissions. Transportation Research Part D: Transport and Environment, 2005. 10(4): p. 323-340.
63. Rakha, H., et al., Requirements for evaluating traffic signal control impacts on energy and emissions based on instantaneous speed and acceleration measurements.. Transportation Research Record: Journal of the Transportation Research Board, 2000. 1738(1): p. 56-67.

64. De Coensel, B., et al., Effects of traffic signal coordination on noise and air pollutant emissions. Environmental Modelling & Software, 2012. 35: p. 74-83.
65. Chen, K. and L. Yu, Microscopic Traffic-Emission Simulation and Case Study for Evaluation of Traffic Control Strategies. Journal of Transportation Systems Engineering and Information Technology, 2007. 7(1): p. 93-99.
66. Unal, A., N.M. Rouphail, and H.C. Frey. Effect of arterial signalization and level of service on measured vehicle emissions. in Proceedings of the 82nd Annual Meeting of the Transportation Research Board. 2003. Washington D.C., USA.
67. Zhang, Y., et al., Assessing effect of traffic signal control strategies on vehicle emissions. Journal of Transportation Systems Engineering and Information Technology, 2009. 9(1): p. 150-155.
68. Rakha, H., et al., Traffic signal coordination across jurisdictional boundaries: Field evaluation of efficiency, energy, environmental, and safety impacts. Transportation Research Record: Journal of the Transportation Research Board, 2000 (1727): p. 42-51.
69. Yannis, G., E. Papadimitriou, and P. Evgenikos. Effectiveness of road safety measures at junctions. Proceedings of the 1st International Conference on Access Management, Athens. 2011.
70. Li, W. and A. Tarko, Effect of arterial signal coordination on safety. Transportation Research Record: Journal of the Transportation Research Board, 2011(2237): p. 51-59.
71. Dowling, R.G., et al., Predicting Air Quality Effects of Traffic-Flow Improvements: Final Report and User's Guide. NCHRP Report 535. 2005: Transportation Research Board.
72. Keller, J., et al., The impact of reducing the maximum speed limit on motorways in Switzerland to 80 km/h on emissions and peak ozone. Environmental Modelling & Software, 2008. 23(3): p. 322-332.
73. Gonçalves, M., et al., Air quality models sensitivity to on-road traffic speed representation: Effects on air quality of 80 km/h speed limit in the Barcelona Metropolitan area. Atmospheric Environment, 2008. 42(36): p. 8389-8402.
74. Dijkema, M.B.A., et al., Air quality effects of an urban highway speed limit reduction. Atmospheric Environment, 2008. 42(40): p. 9098-9105.
75. Pant, P. and R.M. Harrison, Estimation of the contribution of road traffic emissions to particulate matter concentrations from field measurements: a review. Atmospheric Environment, 2013. 77: p. 78-97.
76. Weinbruch, S., et al., A quantitative estimation of the exhaust, abrasion and resuspension components of particulate traffic emissions using electron microscopy. Atmospheric Environment, 2014. 99: p. 175-182.
77. Gustafsson, M., et al., Properties and toxicological effects of particles from the interaction between tyres, road pavement and winter traction material. Science of the Total Environment, 2008. 393(2): p. 226-240.
78. Kuhns, H., et al., Testing re-entrained aerosol kinetic emissions from roads: a new approach to infer silt loading on roadways.. Atmospheric Environment, 2001. 35(16): p. 2815-2825.
79. Moore, V.M., J. Dolinis, and A.J. Woodward, Vehicle speed and risk of a severe crash. Epidemiology, 1995. 6(3): p. 258-262.
80. Caltrans California Manual for Setting Speed Limits. 2014.
81. Ott, W., N. Klepeis, and P. Switzer, Air change rates of motor vehicles and in-vehicle pollutant concentrations from secondhand smoke. Journal of Exposure Science and Environmental Epidemiology, 2008. 18(3): p. 312-325.
82. Baik, J.-J. and J.-J. Kim, A numerical study of flow and pollutant dispersion characteristics in urban street canyons.. Journal of Applied Meteorology, 1999. 38(11): p. 1576-1589.
83. Chan, A.T., W.T.W. Au, and E.S.P. So, Strategic guidelines for street canyon geometry to achieve sustainable street air quality—part II: multiple canopies and canyons. Atmospheric Environment, 2003. 37(20): p. 2761-2772.
84. Chan, A.T., E.S.P. So, and S.C. Samad, Strategic guidelines for street canyon geometry to achieve sustainable street air quality. Atmospheric Environment, 2001. 35(32): p. 5681-5691.

85. Chang, C.-H. and R.N. Meroney, Concentration and flow distributions in urban street canyons: wind tunnel and computational data. Journal of Wind Engineering and Industrial Aerodynamics, 2003. 91(9): p. 1141-1154.
86. Vardoulakis, S., et al., Modelling air quality in street canyons: a review. Atmospheric Environment, 2003. 37(2): p. 155-182.
87. Boarnet, M.G., et al., Fine Particulate Concentrations Near Arterial Streets: The Influence of Building Placement and Wind Flow. 2010: University of California Transportation Center Publication.
88. Salmond, J.A., et al., Vertical transport of accumulation mode particles between two street canyons and the urban boundary layer. Atmospheric Environment, 2010. 44(39): p. 5139-5147.
89. Gu, Z.L., et al., Effect of uneven building layout on air flow and pollutant dispersion in non-uniform street canyons. Building and Environment, 2011. 46(12): p. 2657-2665.
90. Chau, C.K., et al., Study of the PM 10 concentration variations along two intra-urban roads within a compact city. Environmental Monitoring and Assessment, 2012. 184(6): p. 3943-3958.
91. Hang, J., et al., On the contribution of mean flow and turbulence to city breathability: The case of long streets with tall buildings. Science of the Total Environment, 2012. 416: p. 362-373.
92. Tong, N.Y.O. and D.Y.C. Leung, Effects of building aspect ratio, diurnal heating scenario, and wind speed on reactive pollutant dispersion in urban street canyons. Journal of Environmental Sciences, 2012. 24(12): p. 2091-2103.
93. Oke, T.R., Street design and urban canopy layer climate. Energy and Buildings, 1988. 11(1–3): p. 103-113.
94. Ng, E., Policies and technical guidelines for urban planning of high-density cities – air ventilation assessment (AVA) of Hong Kong. Building and Environment, 2009. 44(7): p. 1478-1488.
95. Ng, E., et al., Improving the wind environment in high-density cities by understanding urban morphology and surface roughness: A study in Hong Kong. Landscape and Urban Planning, 2011. 101(1): p. 59-74.
96. Spirn, A.W., Air Quality at Street-Level: Strategies for Urban Design, Boston Redevelopment. Authority, Editor. 1986.
97. McNabola, A., New Directions: Passive control of personal air pollution exposure from traffic emissions in urban street canyons. Atmospheric Environment, 2010. 44(24): p. 2940-2941.
98. Van Dingenen, R., et al., A European aerosol phenomenology—physical characteristics of particulate matter at kerbside, urban, rural and background sites in Europe. Atmospheric Environment, 2004. 38(16): p. 2561-2577.
99. Fisher, B., et al., Meteorology applied to urban air pollution problems: concepts from COST 715. Atmospheric Chemistry and Physics Discussions, 2006. 6(2): p. 555-564.
100. Chan, T.L., et al., Validation of a two-dimensional pollutant dispersion model in an isolated street canyon. Atmospheric Environment, 2002. 36(5): p. 861-872.
101. Theurer, W., Typical building arrangements for urban air pollution modelling. Atmospheric Environment, 1999. 33(24–25): p. 4057-4066.
102. Baik, J.-J., et al., A laboratory model of urban street-canyon flows. Journal of Applied Meteorology, 2000. 39(9): p. 1592-1600.
103. Tomlin, A.S., et al., A field study of factors influencing the concentrations of a traffic-related pollutant in the vicinity of a complex urban junction. Atmospheric Environment, 2009. 43(32): p. 5027-5037.
104. Vardoulakis, S., N. Gonzalez-Flesca, and B.E.A. Fisher, Assessment of traffic-related air pollution in two street canyons in Paris: implications for exposure studies. Atmospheric Environment, 2002. 36(6): p. 1025-1039.
105. Xie, S., et al., Spatial distribution of traffic-related pollutant concentrations in street canyons. Atmospheric Environment, 2003. 37(23): p. 3213-3224.
106. Xie, X., Z. Huang, and J.-s. Wang, Impact of building configuration on air quality in street canyon. Atmospheric Environment, 2005. 39(25): p. 4519-4530.

107. Weber, S., W. Kuttler, and K. Weber, Flow characteristics and particle mass and number concentration variability within a busy urban street canyon. Atmospheric Environment, 2006. 40(39): p. 7565-7578.
108. Dobre, A., et al., Flow field measurements in the proximity of an urban intersection in London, UK. Atmospheric Environment, 2005. 39(26): p. 4647-4657.
109. Sini, J.-F., S. Anquetin, and P.G. Mestayer, Pollutant dispersion and thermal effects in urban street canyons. Atmospheric Environment, 1996. 30(15): p. 2659-2677.
110. Chan, L.Y. and W.S. Kwok, Vertical dispersion of suspended particulates in urban area of Hong Kong. Atmospheric Environment, 2000. 34(26): p. 4403-4412.
111. Boarnet, M.G., et al., Fine particulate concentrations on sidewalks in five Southern California cities. Atmospheric Environment, 2011. 45(24): p. 4025-4033.
112. Hang, J., et al., The influence of building height variability on pollutant dispersion and pedestrian ventilation in idealized high-rise urban areas. Building and Environment, 2012. 56: p. 346-360.
113. Schulte, N., S. Tan, and A. Venkatram, The ratio of effective building height to street width governs dispersion of local vehicle emissions. Atmospheric Environment, 2015. 112: p. 54-63.
114. Kaur, S., M.J. Nieuwenhuijsen, and R.N. Colvile, Fine particulate matter and carbon monoxide exposure concentrations in urban street transport microenvironments. Atmospheric Environment, 2007. 41(23): p. 4781-4810.
115. Hess, D.B., et al., Determinants of exposure to fine particulate matter (PM2.5) for waiting passengers at bus stops. Atmospheric Environment, 2010. 44(39): p. 5174-5182.
116. Bady, M., et al., An experimental investigation of the wind environment and air quality within a densely populated urban street canyon. Journal of Wind Engineering and Industrial Aerodynamics, 2011. 99(8): p. 857-867.
117. Ng, W.Y. and C.K. Chau, Evaluating the role of vegetation on the ventilation performance in isolated deep street canyons. International Journal of Environment and Pollution, 2012. 50(1-4): p. 98-110.
118. Xie, X., et al., The impact of solar radiation and street layout on pollutant dispersion in street canyon. Building and Environment, 2005. 40(2): p. 201-212.
119. Yassin, M.F., Impact of height and shape of building roof on air quality in urban street canyons. Atmospheric Environment, 2011. 45(29): p. 5220-5229.
120. Huang, Y.-d., M.-x. Jin, and Y.-n. Sun, Numerical studies on airflow and pollutant dispersion in urban street canyons formed by slanted roof buildings. Journal of Hydrodynamics, Ser. B, 2007. 19(1): p. 100-106.
121. Acero, J.A., et al., Impact of local urban design and traffic restrictions on air quality in a medium-sized town. Environmental Technology, 2012. 33(21): p. 2467-2477.
122. Zhu, Y., et al., Effects of Complete Streets on Travel Behavior and Exposure to Vehicular Emissions, final report to the Air Resources Board, Contract #11-312. 2016: UCLA Fielding School of Public Health, UCLA Luskin School of Public Affairs.
123. Moore, B., "Health Benefits of Physical Activity: Implications for Sustainable Communities", June 25, 2015 California Air Resources Board Meeting. 2015: Sacramento, CA.
124. Hagler, G.S.W., et al., Field investigation of roadside vegetative and structural barrier impact on near-road ultrafine particle concentrations under a variety of wind conditions. Science of the Total Environment, 2012. 419: p. 7-15.
125. Ning, Z., et al., Impact of roadside noise barriers on particle size distributions and pollutants concentrations near freeways. Atmospheric Environment, 2010. 44(26): p. 3118-3127.
126. McNabola, A., B.M. Broderick, and L.W. Gill, Reduced exposure to air pollution on the boardwalk in Dublin, Ireland. Measurement and prediction. Environment International, 2008. 34(1): p. 86-93.
127. Finn, D., et al., Tracer studies to characterize the effects of roadside noise barriers on near-road pollutant dispersion under varying atmospheric stability conditions. Atmospheric Environment, 2010. 44(2): p. 204-214.
128. Bowker, G.E., et al., The effects of roadside structures on the transport and dispersion of ultrafine particles from highways. Atmospheric Environment, 2007. 41(37): p. 8128-8139.

129. Heist, D.K., S.G. Perry, and L.A. Brixey, A wind tunnel study of the effect of roadway configurations on the dispersion of traffic-related pollution. Atmospheric Environment, 2009. 43(32): p. 5101-5111.
130. Schulte, N., et al., Effects of solid barriers on dispersion of roadway emissions. Atmospheric Environment, 2014. 97: p. 286-295.
131. Handy, S., et al. SB 375 Policy Brief: Impacts of Network Connectivity on Passenger Vehicle Use and Greenhouse Gas Emissions. 2014.
132. Hendriks, R., et al., Technical Noise Supplement to the Traffic Noise Analysis Protocol, California Department of Transportation. September 2013.
133. Stansfeld, S.A. and M.P. Matheson, Noise pollution: non-auditory effects on health. British Medical Bulletin, 2003. 68(1): p. 243-257.
134. Arenas, J.P., Potential problems with environmental sound barriers when used in mitigating surface transportation noise. Science of the Total Environment, 2008. 405(1): p. 173-179.
135. FHWA Office of Planning, Environment, and Realty. Highway Traffic Noise. [cited 2015 October 22]; Available from: http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/keepdown.cfm.
136. Jeanjean, A., et al., A CFD study on the effectiveness of trees to disperse road traffic emissions at a city scale. Atmospheric Environment, 2015. 120: p. 1-14.
137. Cavanagh, J.-A.E., P. Zawar-Reza, and J.G. Wilson, Spatial attenuation of ambient particulate matter air pollution within an urbanised native forest patch. Urban Forestry & Urban Greening, 2009. 8(1): p. 21-30.
138. Yin, S., et al., Quantifying air pollution attenuation within urban parks: An experimental approach in Shanghai, China. Environmental Pollution, 2011. 159(8–9): p. 2155-2163.
139. Khan, F. and S.A. Abbasi, Attenuation of gaseous pollutants by greenbelts. Environmental Monitoring and Assessment, 2000. 64(2): p. 457-475.
140. Islam, M.N., et al., Pollution attenuation by roadside greenbelt in and around urban areas. Urban Forestry & Urban Greening, 2012. 11(4): p. 460-464.
141. Brantley, H.L., et al., Field assessment of the effects of roadside vegetation on near-road black carbon and particulate matter. Science of the Total Environment, 2014. 468–469: p. 120-129.
142. Steffens, J.T., Y.J. Wang, and K.M. Zhang, Exploration of effects of a vegetation barrier on particle size distributions in a near-road environment. Atmospheric Environment, 2012. 50: p. 120-128.
143. Fuller, M. and F. Bombardelli, Particulate Matter Modeling in Near-Road Vegetation Environments. UC Davis-Caltrans Air Quality Project, 2009.
144. Tong, Z., et al., Roadside vegetation barrier designs to mitigate near-road air pollution impacts. Science of the Total Environment, 2016. 541: p. 920-927.
145. Maher, B.A., et al., Impact of roadside tree lines on indoor concentrations of traffic-derived particulate matter. Environmental Science & Technology, 2013. 47(23): p. 13737-13744.
146. Vos, P.E.J., et al., Improving local air quality in cities: To tree or not to tree? Environmental Pollution, 2013. 183: p. 113-122.
147. Wania, A., et al., Analysing the influence of different street vegetation on traffic-induced particle dispersion using microscale simulations. Journal of Environmental Management, 2012. 94(1): p. 91-101.
148. Salmond, J.A., et al., The influence of vegetation on the horizontal and vertical distribution of pollutants in a street canyon. Science of the Total Environment, 2013. 443: p. 287-298.
149. Buccolieri, R., et al., Aerodynamic effects of trees on pollutant concentration in street canyons. Science of the Total Environment, 2009. 407(19): p. 5247-5256.
150. Gromke, C. and B. Ruck, Influence of trees on the dispersion of pollutants in an urban street canyon—Experimental investigation of the flow and concentration field. Atmospheric Environment, 2007. 41(16): p. 3287-3302.
151. Chameides, W., et al., The role of biogenic hydrocarbons in urban photochemical smog: Atlanta as a case study. Science, 1988. 241(4872): p. 1473-1475.

152. Bhangar, S., et al., Ultrafine particle concentrations and exposures in seven residences in northern California. Indoor Air, 2011. 21(2): p. 132-144.
153. Less, B., et al., Indoor air quality in 24 California residences designed as high-performance homes. Science and Technology for the Built Environment, 2015. 21(1): p. 14-24.
154. Singer, B.C., et al., Reducing In-Home Exposure to Air Pollution, Final report to the Air Resources Board, Contract #11-311. 2015: Lawrence Berkeley National Laboratory.
155. MacIntosh, D.L., et al., Whole house particle removal and clean air delivery rates for in-duct and portable ventilation systems.. Journal of the Air & Waste Management Association, 2008. 58(11): p. 1474-1482.
156. Stephens, B. and J.A. Siegel, Comparison of test methods for determining the particle removal efficiency of filters in residential and light-commercial central HVAC systems. Aerosol Science and Technology, 2011. 46(5): p. 504-513.
157. Brown, K.W., et al., Reducing patients' exposures to asthma and allergy triggers in their homes: an evaluation of effectiveness of grades of forced air ventilation filters. Journal of Asthma, 2014. 51(6): p. 585-594.
158. MacIntosh, D.L., et al., The benefits of whole-house in-duct air cleaning in reducing exposures to fine particulate matter of outdoor origin: A modeling analysis. Journal of Exposure Science and Environmental Epidemiology, 2010. 20(2): p. 213-224.
159. Stephens, B. and J.A. Siegel, Ultrafine particle removal by residential heating, ventilating, and air-conditioning filters. Indoor Air, 2013. 23(6): p. 488-497.
160. Morawska, L., et al., Variation in indoor particle number and PM2.5 concentrations in a radio station surrounded by busy roads before and after an upgrade of the HVAC system. Building and Environment, 2009. 44(1): p. 76-84.
161. Azimi, P., D. Zhao, and B. Stephens, Estimates of HVAC filtration efficiency for fine and ultrafine particles of outdoor origin. Atmospheric Environment, 2014. 98: p. 337-346.
162. Parker, J.L., et al., Particle size distribution and composition in a mechanically ventilated school building during air pollution episodes. Indoor Air, 2008. 18(5): p. 386-393.
163. Polidori, A., et al., Pilot study of high-performance air filtration for classroom applications. Indoor Air, 2013. 23(3): p. 185-195.
164. Wu, X., M.G. Apte, and D.H. Bennett, Indoor particle levels in small- and medium-sized commercial buildings in California.. Environmental Science & Technology, 2012. 46(22): p. 12355-12363.
165. Zaatari, M., A. Novoselac, and J. Siegel, The relationship between filter pressure drop, indoor air quality, and energy consumption in rooftop HVAC units. Building and Environment, 2014. 73: p. 151-161.
166. Hacker, D.W. and E.M. Sparrow, Use of air-cleaning devices to create airborne particle-free spaces intended to alleviate allergic rhinitis and asthma during sleep. Indoor Air, 2005. 15(6): p. 420-431.
167. Shaughnessy, R.J. and R.G. Sextro, What is an effective portable air cleaning device? A Review. Journal of Occupational and Environmental Hygiene, 2006. 3(4): p. 169-181.
168. Skulberg, K.R., et al., The effects of intervention with local electrostatic air cleaners on airborne dust and the health of office employees. Indoor Air, 2005. 15(3): p. 152-159.
169. Ward, M., J.A. Siegel, and R.L. Corsi, The effectiveness of stand alone air cleaners for shelter-in-place. Indoor Air, 2005. 15(2): p. 127-134.
170. Sublett, J., Effectiveness of air filters and air cleaners in allergic respiratory diseases: A review of the recent literature.. Current Allergy and Asthma Reports, 2011. 11(5): p. 395-402.
171. Wu, G., et al., Energy and emission benefit comparison of stationary and in-vehicle advanced driving alert systems. Transportation Research Record: Journal of the Transportation Research Board, 2010(2189): p. 98-106.
172. Panis, L., S. Broekx, and R. Liu, Modelling instantaneous traffic emission and the influence of traffic speed limits. Science of the Total Environment, 2006. 371(1–3): p. 270-285.
173. Atkinson, R.W., et al., The impact of the congestion charging scheme on ambient air pollution concentrations in London. Atmospheric Environment, 2009. 43(34): p. 5493-5500.

174. Beevers, S.D. and D.C. Carslaw, The impact of congestion charging on vehicle emissions in London. Atmospheric Environment, 2005. 39(1): p. 1-5.
175. Tonne, C., et al., Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities. Occupational and Environmental Medicine, 2008. 65(9): p. 620-627.
176. Johansson, C., L. Burman, and B. Forsberg, The effects of congestions tax on air quality and health. Atmospheric Environment, 2009. 43(31): p. 4843-4854.
177. Carslaw, D.C. and S.D. Beevers, The efficacy of low emission zones in central London as a means of reducing nitrogen dioxide concentrations. Transportation Research Part D: Transport and Environment, 2002. 7(1): p. 49-64.
178. Panteliadis, P., et al., Implementation of a low emission zone and evaluation of effects on air quality by long-term monitoring. Atmospheric Environment, 2014. 86: p. 113-119.
179. Boogaard, H., et al., Impact of low emission zones and local traffic policies on ambient air pollution concentrations. Science of the Total Environment, 2012. 435–436: p. 132-140.
180. Acero, J.A., et al., Impact of local urban design and traffic restrictions on air quality in a medium-sized town. Environmental Technology, 2012. 33(21): p. 2467-2477.
181. Chiquetto, S., The environmental impacts from the implementation of a pedestrianization scheme. Transportation Research Part D: Transport and Environment, 1997. 2(2): p. 133-146.
182. Höglund, P.G. and J. Niittymäki. Estimating vehicle emissions and air pollution related to driving patterns and traffic calming. Urban Transport Systems Conference Sweden. 1999.
183. Morawska, L., et al., A study of the horizontal and vertical profile of submicrometer particles in relation to a busy road. Atmospheric Environment, 1999. 33(8): p. 1261-1274.
184. Wu, Y., et al., Vertical and horizontal profiles of airborne particulate matter near major roads in Macao, China. Atmospheric Environment, 2002. 36(31): p. 4907-4918.
185. Li, C., et al., Vertical distribution of PAHs in the indoor and outdoor PM2.5 in Guangzhou, China. Building and Environment, 2005. 40(3): p. 329-341.
186. Tao, S., et al., Vertical distribution of polycyclic aromatic hydrocarbons in atmospheric boundary layer of Beijing in winter. Atmospheric Environment, 2007. 41(40): p. 9594-9602.
187. Wu, C.-D., et al., Mapping the vertical distribution of population and particulate air pollution in a near-highway urban neighborhood: Implications for exposure assessment. Journal of Exposure Science and Environmental Epidemiology, 2014. 24(3): p. 297-304.
188. Jung, K.H., et al., Effects of floor level and building type on residential levels of outdoor and indoor polycyclic aromatic hydrocarbons, black carbon, and particulate matter in New York City. Atmosphere, 2011. 2(2): p. 96-109.
189. Zhou, Y. and J.I. Levy, The impact of urban street canyons on population exposure to traffic-related primary pollutants. Atmospheric environment, 2008. 42(13): p. 3087-3098.
190. Baldauf, R.W., T. A. Cahill, C. Bailey, A. Khlystov, K. M. Zang, R. Cook, C. Cowherd, and G. E. Bowker. Can roadway design be used to mitigate air quality impacts from traffic? EM: Air and Waste Management Association's Magazine for Environmental Managers, 2009(8): p. 1-5.
191. Baldauf, R.W., et al., Air quality variability near a highway in a complex urban environment. Atmospheric Environment, 2013. 64: p. 169-178.
192. Cahill, T.A., et al., Contribution of Freeway Traffic to Airborne Particulate Matter, Final report to the Air Resources Board, Contract #05-340. 1973.
193. Van Poppel, M., et al., A comparative study of traffic related air pollution next to a motorway and a motorway flyover. Atmospheric Environment, 2012. 60: p. 132-141.
194. Nikolaou, M., Traffic Air Pollution Effects of Elevated, Depressed, and At-Grade Level Freeways in Texas. 1997, The Texas A & M University.
195. Hertel, O., et al., A proper choice of route significantly reduces air pollution exposure — A study on bicycle and bus trips in urban streets. Science of the Total Environment, 2008. 389(1): p. 58-70.

196. Kendrick, C., et al., Impact of bicycle lane characteristics on exposure of bicyclists to traffic-related particulate matter. Transportation Research Record: Journal of the Transportation Research Board, 2011(2247): p. 24-32.
197. Cole-Hunter, T., et al., Inhaled particle counts on bicycle commute routes of low and high proximity to motorised traffic. Atmospheric Environment, 2012. 61: p. 197-203.
198. Hatzopoulou, M., et al., A web-based route planning tool to reduce cyclists' exposures to traffic pollution: A case study in Montreal, Canada. Environmental Research, 2013. 123: p. 58-61.
199. Cowie, C.T., et al., Redistribution of traffic related air pollution associated with a new road tunnel. Environmental Science & Technology, 2012. 46(5): p. 2918-2927.
200. Burr, M.L., et al., Effects on respiratory health of a reduction in air pollution from vehicle exhaust emissions. Occupational and Environmental Medicine, 2004. 61(3): p. 212-218.
201. Karner, A., et al., Mitigating diesel truck impacts in environmental justice communities: Transportation planning and air quality in Barrio Logan, San Diego, California. Transportation Research Record: Journal of the Transportation Research Board, 2009(2125): p. 1-8.
202. Castro, J.T. and M.R. Delos Reyes, Estimating traffic and emissions for various scenarios of freight vehicle restrictions in metro manila. Asian Transport Studies, 2010. 1(1): p. 4-17.
203. Zhang, K., S. Batterman, and F. Dion, Vehicle emissions in congestion: Comparison of work zone, rush hour and free-flow conditions. Atmospheric Environment, 2011. 45(11): p. 1929-1939.
204. Demir, E., T. Bektas, and G. Laporte, A review of recent research on green road freight transportation. European Journal of Operational Research, 2014. 237(3): p. 775-793.
205. Zhang, Y., et al., Can commonly-used fan-driven air cleaning technologies improve indoor air quality? A literature review. Atmospheric Environment, 2011. 45(26): p. 4329-4343.
206. Batterman, S., C. Godwin, and C. Jia, Long duration tests of room air filters in cigarette smokers' homes.. Environmental Science & Technology, 2005. 39(18): p. 7260-7268.
207. Chen, W., J. Zhang, and Z. Zhang, Performance of air cleaners for removing multiple volatile organic compounds in indoor air. ASHRAE Transactions, 2005. 111 (1): p. 1101-1114.
208. Sidheswaran, M.A., et al., Energy efficient indoor VOC air cleaning with activated carbon fiber (ACF) filters. Building and Environment, 2012. 47: p. 357-367.
209. Qu, F., L. Zhu, and K. Yang, Adsorption behaviors of volatile organic compounds (VOCs) on porous clay heterostructures (PCH). Journal of Hazardous Materials, 2009. 170(1): p. 7-12.
210. Tsai, J.-H., et al., Adsorption characteristics of acetone, chloroform and acetonitrile on sludge-derived adsorbent, commercial granular activated carbon and activated carbon fibers. Journal of Hazardous Materials, 2008. 154(1–3): p. 1183-1191.
211. Zaitan, H., et al., A comparative study of the adsorption and desorption of o-xylene onto bentonite clay and alumina. Journal of Hazardous Materials, 2008. 153(1–2): p. 852-859.
212. Guieysse, B., et al., Biological treatment of indoor air for VOC removal: Potential and challenges. Biotechnology Advances, 2008. 26(5): p. 398-410.
213. Hodgson, A.T., et al., Performance of ultraviolet photocatalytic oxidation for indoor air cleaning applications. Indoor Air, 2007. 17(4): p. 305-316.
214. Destaillats, H., M. Sleiman, and W.J. Fisk, Evaluation of Pollutant Emissions from Portable Air Cleaners. Final report to the Air Resources Board. Contract #10-320: Lawrence Berkeley National Laboratory.
215. Coleman, B.K., et al., Secondary organic aerosol from ozone-initiated reactions with terpene-rich household products. Atmospheric Environment, 2008. 42(35): p. 8234-8245.
216. Nazaroff, W.W. and C.J. Weschler, Cleaning products and air fresheners: exposure to primary and secondary air pollutants. Atmospheric Environment, 2004. 38(18): p. 2841-2865.
217. Singer, B.C., et al., Indoor secondary pollutants from cleaning product and air freshener use in the presence of ozone. Atmospheric Environment, 2006. 40(35): p. 6696-6710.
218. Quoc An, H.T., et al., Application of atmospheric non thermal plasma-catalysis hybrid system for air pollution control: Toluene removal. Catalysis Today, 2011. 176(1): p. 474-477.

219. Destaillats, H., et al., Key parameters influencing the performance of photocatalytic oxidation (PCO) air purification under realistic indoor conditions. Applied Catalysis B: Environmental, 2012. 128: p. 159-170.
220. Hill, A.C., Vegetation: A sink for atmospheric pollutants. Journal of the Air Pollution Control Association, 1971. 21(6): p. 341-346.
221. Beckett, K.P., P.H. Freer-Smith, and G. Taylor, Urban woodlands: their role in reducing the effects of particulate pollution. Environmental Pollution, 1998. 99(3): p. 347-360.
222. Beckett, K.P., P.H. Freer-Smith, and G. Taylor, Particulate pollution capture by urban trees: Effect of species and windspeed. Global Change Biology, 2000. 6(8): p. 995-1003.
223. Dzierzanowski, K., et al., Deposition of particulate matter of different size fractions on leaf surfaces and waxes of urban forest species.. International Journal of Phytoremediation, 2011. 13(10): p. 1037-1046.
224. Lin, M.-Y. and A. Khlystov, Investigation of ultrafine particle deposition to vegetation branches in a wind tunnel. Aerosol Science and Technology, 2011. 46(4): p. 465-472.
225. Nowak, D.J., D.E. Crane, and J.C. Stevens, Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening, 2006. 4(3–4): p. 115-123.
226. McDonald, A.G., et al., Quantifying the effect of urban tree planting on concentrations and depositions of PM10 in two UK conurbations. Atmospheric Environment, 2007. 41(38): p. 8455-8467.
227. Tallis, M., et al., Estimating the removal of atmospheric particulate pollution by the urban tree canopy of London, under current and future environments. Landscape and Urban Planning, 2011. 103(2): p. 129-138.
228. Nowak, D.J., et al., Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. Environmental Pollution, 2013. 178: p. 395-402.
229. Donovan, R.G., et al., Development and application of an urban tree air quality score for photochemical pollution episodes using the Birmingham, United Kingdom area as a case study. Environmental Science & Technology., 2005. 39(17): p. 6730-6738.
230. Currie, B. and B. Bass, Estimates of air pollution mitigation with green plants and green roofs using the UFORE model. Urban Ecosystems, 2008. 11(4): p. 409-422.
231. Yang, J., Q. Yu, and P. Gong, Quantifying air pollution removal by green roofs in Chicago. Atmospheric Environment, 2008. 42(31): p. 7266-7273.
232. Baik, J.-J., et al., Effects of building roof greening on air quality in street canyons. Atmospheric Environment, 2012. 61: p. 48-55.
233. Pugh, T.A.M., et al., Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons. Environmental Science & Technology, 2012. 46(14): p. 7692-7699.
234. Escobedo, F.J. and D.J. Nowak, Spatial heterogeneity and air pollution removal by an urban forest. Landscape and Urban Planning, 2009. 90(3–4): p. 102-110.
235. Speak, A.F., et al., Urban particulate pollution reduction by four species of green roof vegetation in a UK city. Atmospheric Environment, 2012. 61: p. 283-293.
236. Pugh, T.A.M., et al., Effectiveness of green infrastructure for improvement of air quality in urban street canyons. Environmental Science & Technology, 2012. 46(14): p. 7692-7699.

EXHIBIT 3

Dorsey Marketplace FEIR Response to Comments, Dorsey Marketplace Final EIR October, 2019 (FEIR)

Technical comments regarding Biological Resources

A revised version of Appendix E has been provided below.
http://www.cityofgrassvalley.com/files/attachments/news-notices/appendix_e.pdf

The EIR and Biological Resources Technical Appendix E (Original and Revised) are materially defective and lack the information needed to understand the impacts of the project on the biological resources and develop adequate mitigation.

Issue 1. Appendix E evaluated the site at a level that was insufficient to identify the potential ecological impacts of the project to special status species and sensitive habitats. Where impacts were identified, in some cases the impact analysis was changed to lower biological impacts on the basis of an asserted new field survey, without any new supporting technical information; and, the qualifications of the field staff are unsubstantiated.

The FEIR itself identifies that there were material defects in the preparation of the Appendix E, Biological Technical Report in Comments G-2. p.2-51 and S2 p.2-332. The publically available version of the Biological Technical Report provided in the DEIR dated July 2016 was revised **August 2019** with "new" information. The revised version has been provided below.
http://www.cityofgrassvalley.com/files/attachments/news-notices/appendix_e.pdf

On p. 17, the revised Appendix E Biological Technical Report identified different USGAS quadrangles (from the incorrect Bay Area to the project site).

On p.18, the revised Appendix E Biological Technical Report identified a new, previously undisclosed site survey, one that purportedly happened during the more appropriate period for rare plant surveys, the July 2016 survey. The report completed in July identified that there was the potential for special status plants that required additional surveys, a conclusion that was changed in the August revised draft. (p.23)

On p.18, the text was changed from "survey" to "surveys", and the conclusion that the survey was not completed during the appropriate blooming period was altered to state that a second survey was completed during the appropriate period to identify specials-status plants. Plural language for surveys was added throughout the section.

On p.18, the list of special status plants was changed from Dubious Pea, a California Rare Plant Rank 3, which was deleted, to add the new sensitive species, Follett's monardella which is a 1.B2 status (Rare, endangered or threatened). The pea is found very close to the project site, within a 1/3 of a mile according to the original Appendix E.

The pea was removed from Biological Technical Report analysis 3 years later. The pea was struck from the Biological Technical Report as the *approach in the FEIR* changed from including special status species with potential to occur at the site, to only reviewing those species if their status was classified California Rare Plant Rank extinct or rare, threatened or endangered (1A, 1B or 2). Having a CEQA consultant changes the results of a Biological Technical Report 3 years after the fact to support the FEIR analysis lacks credibility and calls the report and the FEIR's its conclusions into question. This recasting of the physical surveys to meet the FEIR instead of the analysis being based on the environmental conditions lacks credibility. Moreover the new findings of the 3-year old document also conveniently reduce not just the potential presence of plant species, but also animals.

On p. 20-21, the presence of the elusive Blainville's horned lizard was discounted because of the purported new survey.

On p. 21, another new, sensitive natural community, in addition to the McNabb cypress woodland, the Fremont cottonwood forest was identified. The conclusion of the analysis was changed to state that these communities were now "disturbed' and "isolated". The analysis again fails to identify the sensitive status of the knobcone pine/whiteleaf manzanita community, which was identified in the species list but not in the analysis. See Attachment A, which is also available at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=153609&inline

On p. 21, potentially a third previous site visit is disclosed, with no date or other specifics provided.

On p. 22, another potentially sensitive natural community, a wetland is identified, however, since the wetland vegetation was not identified, it cannot by classified.

On p.23 there is a *revised* conclusion from the potential presence of special status plant species, to absence.

There are specific protocols identified by the California Department of Fish and Wildlife (CDFW) for use when assessing special status plants and sensitive natural communities, Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities (March 20, 2018). Specifically, the CDFW protocol states: "Botanical field surveys and subsequent reporting should be comprehensive and floristic in nature and not restricted to or focused only on a list." (p.5-12) There is no evidence that this or any other formal protocol was used. There are no field notes or details from the field observations, such as photographs identified from each of the visits to substantiate the new site visit. See Attachment B, which is also available at https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18959&inline

Appendix E also contains its own Appendix A, which does provide 'Representative Photographs of the Project Area, A-1 and A-2. All 4 of the photographs are overcast, and do not show any blooms (exc. for the white manzanita) or significant forb or small plant growth. The flowering period for white manzanita is from January to March. See https://plants.usda.gov/plantguide/pdf/pg_arma.pdf. The surveys were identified as occurring March 4 and the new survey on July 22, 2016 (p.11). It does not appear that the consultant provided any photographs from the "July" site visit, nor are there any photographs of the wetland features or the mining features provided in this appendix.

There are no qualifications provided for the survey team, nor are there field notes or any other evidence to substantiate a July site visit. As noted in the original Biological Technical Report, identification of the presence or absence of special status plants requires skilled experts, at the right time, and there is nothing in this record to substantiate those skills with the list of species with potential to occur at the site. Do these consultants meet the definition of qualified biologist identified in Comment S-13? As we have documented, they even failed to correctly identify at least one obvious sensitive natural community.

Issue2. The wrong standard was applied to plant species.

The FEIR identifies that there were material defects in the preparation of the Appendix E, Biological Technical Report. The publically available version provided in the DEIR dated July 2016 and revised August 2019 version has systematic errors in analysis as well as the previously discussed field identification errors.

On p. 6 of Appendix E there is a description of portions of the California Native Plant Protection Act:

> *The California Native Plant Protection Act (California Fish and Game Code Sections 1900-1913) and the Natural Communities Conservation Planning Act provide guidance on the preservation of plant resources. Vascular plants which have no designated status or protection under state or federal endangered species legislation, but are listed as rare or endangered by the CNPS, are defined as follows:*
>
> > *1. California Rare Plant Rank (CRPR) 1A: Plants presumed extinct*
> > *2. CRPR 1B: Plants rare, threatened, or endangered in California and elsewhere*
> > *3. CRPR 2: Plants rare, threatened, or endangered in California, but more numerous elsewhere*
> > *4. CRPR 3: Plants about which more information is needed – a review list*
> > *5. CRPR 4: Plants of limited distribution – a watch list*
>
> *Generally, plants on CRPR 1A, 1B, or 2 are considered to meet the criteria for endangered, threatened or rare species as outlined by Section 15380 of the CEQA Guidelines. Additionally, plants listed on CNPS List 1A, 1B, or 2 also meet the definition of Section 1901, Chapter 10 (Native Plant Protection Act) and Sections 2062 and 2067 (CESA) of the California Fish and Game Code.*

This analysis is incorrect as it make an unsubstantiated assertion that 14 CCR § 15380 does not involve other criteria, which can include CRPR 3 and 4 listed species (variously in DDEIR/FEIR as CNPS or CRPR). Pursuant to § 15380 under Section (d):" A species not included in any listing identified in subdivision (c) shall nevertheless be considered to be endangered, rare or threatened, if the species can be shown to meet the criteria in subdivision (b)."

Pursuant to Comments S-2 and G-2, the preparers failed to provide *any analysis* to assess the potential for the identified CRPR 3 and 4 species to meet these criteria. That analysis would specifically consider collection of information regarding the extent and location of previous observations, status and trends analysis of those observations, and coordination with species' experts. Yet in the response provided by the agency in S-5 (p. 2-335), the FEIR acknowledges that is the standard approach, but then does not apply those actions to its review of CRPR3 and 4.

Instead, the FEIR provide a table: Table 2-4: CNPS Rank 3 and 4 Plants Warrants for Inclusion in CEQA Review, which identifies in the further right column, that there is simply no need to review: "Inclusion in CEQA Review Warranted (Y/N)." Of course all species identified on the table do not warrant review, but no substantiation is provided. There is no expert analysis that these have been considered: lead agency's discretion on a case-by-case basis determined by local rarity, species range, and threats. (p.2-335)

Conversely, the California Native Plant Society (CNPS)[1] has a clear and legally precise interpretation of the statute:

> *California Rare Plant Rank 3: Plants About Which More Information is Needed - A Review List*
>
> *Plants with a California Rare Plant Rank of 3 are united by one common theme - we lack the necessary information to assign them to one of the other ranks or to reject them. Nearly all of the plants constituting California Rare Plant Rank 3 are taxonomically problematic. For each California Rare Plant Rank 3 plant we have provided the known information and indicated in the "Notes" section of the CNPS Inventory record where assistance is needed. Data regarding distribution, endangerment, ecology, and taxonomic validity are welcomed and can be submitted by emailing the Rare Plant Program at rareplants@cnps.org.*
>
> *Many of the plants constituting California Rare Plant Rank 3 meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and are eligible for state listing. Impacts to these species or their habitat should be analyzed during preparation of environmental documents relating to CEQA, or those considered to be functionally equivalent to CEQA, as they may meet the definition of Rare or Endangered under CEQA Guidelines §15125 (c) and/or §15380.*
>
> *California Rare Plant Rank 4: Plants of Limited Distribution - A Watch List*
>
> *Plants with a California Rare Plant Rank of 4 are of limited distribution or infrequent throughout a broader area in California, and their status should be monitored regularly. Should the degree of endangerment or rarity of a California Rare Plant Rank 4 plant change, we will transfer it to a more appropriate rank.*
>
> *Some of the plants constituting California Rare Plant Rank 4 meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and few, if any, are eligible for state listing. Nevertheless, many of them are significant locally, and we strongly recommend that California Rare Plant Rank 4 plants be evaluated for impact significance during preparation of environmental documents relating to CEQA, or those considered to be functionally equivalent to CEQA, based on CEQA Guidelines §15125 (c) and/or §15380. (Underline Emphasis added.)*

The FEIR preparers and the consultants who prepared and then revised the Appendix E of the DEIR failed to adequately consider the potential legal status of the CRPR/CNPS 3 and 4 listed plants. This error allows for biological impacts to compound by simply ignoring species with potential to be harmed by the project to be simply ignored in the impact analysis. The field work was insufficient to identify special status plants and sensitive communities: In the case of the Rank 3 Dubious Pea, arbitrarily removed from Biological Technical Report, and in the case of the Sensitive natural community, knobcone pine community, simply ignored. The consultant further failed to apply the CDFW survey protocol as well as the § 15380 under Section (d) and the associated CNPS review standard identified above to assess Rank 3 and 4 status species for impacts from the project. This means that there are species, which even if they have been identified (there are 7 species that are identified, but not adequately analyzed [p.2-55]),

[1] See Attachment E, which is also available at http://www.rareplants.cnps.org/glossary.html

have potential significant impacts from this project since they have not been analyzed for impacts from this project.

Issue 3. The failure of analysis further exacerbates the FEIR's failure to apply effective feasible mitigation.

Comment Response G3 p.51-52. The FEIR attempts to cure some of these defects by calling for a future protocol survey as mitigation. The survey would of course be missing all of the G3 and G4 species, since these were removed from consideration in the analysis and thus not be subject to the MMRP. There is no mitigation proposed for those species, contrary to CEQA Guidelines section 15126.4, subdivision (a)(1)(B).

The mitigation measure (6a) calls for a "focused" survey, a survey that focuses its efforts on a specific plant or animal. This is contrary to what the CDFW Protocol states: "Focused surveys" that are limited to habitats known to support special status plants or that are restricted to lists of likely potential special status plants are not considered floristic in nature and are not adequate to identify all plants in a project area to the level necessary to determine if they are special status plants." (CDFW 4-12)

What if a competent biologist identified these special status species in a pre-construction protocol survey (Mitigation Measure 6a)? The FEIR is clear: "However, it is important to note that unless a plant is State or federally listed as Rare, Threatened, or endangered, prior approval from USFWS or CDFW is not required. "(p.2-52) Post-hoc identification of the impacts to special status species is not mitigation, it is a failure of analysis compounded by that inadequacy. There is no path to remedy this injury and no commitment by the lead agency to resolve this defect.

A perfect example of this inadequacy includes the mitigation measure (6e) for the sensitive natural communities one of which was eventually identified:

> Mitigation Measure 6e requires that the project applicant provide compensation for the loss of McNab cypress woodland and cottonwood forest from the project site through a combination of on-site replanting and/or off-site restoration sufficient to ensure no net loss of habitat functions or values in the project region. This would reduce the impact to a less-than-significant level. (p. 6-21)

Conversion of a sensitive natural community to ornamental landscaping is a misuse of the idea of habitat: It is never explained how it would remain functional or how it would ensure habitat values, what densities of which plant species were required, for what species or, for what ecological functions. For example, Webster defines habitat as the place or environment where a plant or animal naturally or normally lives and grows. The proposal to use these plants as landscaping is contrary to the definition of habitat, and provides no defined habitat function. Comment S-20 and S-31 remain effectively unaddressed; there are no criteria to ensure this is functional mitigation.

These biological impacts are potentially cumulative. However the FEIR states that in tortured logic, that if a species is mitigated "to a less than significant level through compliance with the policies and standards identified in the General Plan." (p. 6-22) And further: … requirement that development cause "no net loss of habitat functions or values" through "avoidance of the resource, or through creation or restoration of habitat of superior or comparably quality, in accordance with guidelines of the U.S. Fish and Wildlife Service and the California Department of Fish and Game," In this case there is simply no avoidance of impacts, the impacts will occur and the plants moved or mitigated somewhere offsite. How will this mitigation be successful in meeting restoration of habitat of 'superior or comparably quality' is not clear since there are not guidelines for McNabb and cottonwood forests, and the knobcone special status community is not even identified in the analysis.

Issue 4. The analysis acknowledges multiple failures to identify biological resources, yet doesn't remedy the defects.

For example, pursuant to the question regarding the potential presence of special status bat species which are reasonably likely to be found in a forested area with rock outcroppings and abandoned mine (Comment Response S-3):

> It is noted that the commenter did not conduct a site investigation and therefore has not examined the mine features for suitability as roosting sites. The abandoned onsite mine features consist of relict concrete structures and an apparent shaft. During her site visit, Dudek's biologist noted that the features appeared sealed and no openings suitable for bat entrance and egress were observed. Thus while bat species are known to roost in mine features generally, the features present at the project site do not support bat roosting. Trees onsite consist primarily of ponderosa pine, which could potentially provide roosting habitat for several species of bat. However, the site has limited to no foraging habitat for most bat species because it is isolated and surrounded by development. (FEIR 2-333)

While the commenter did not provide a site investigation, it seems dubious that the consultant did either. It should be noted that apparently there was one site visit by a biologist, (or up to 3 visits, it is difficult to tell), and the qualification and experience of the biologist is unknown, nor are there any provided field notes, just assertions in the response. Yet, this single site visit in complex terrain was sufficient to address the question of bat presence of absence. This response also does not say which if any bat survey protocols were used. There are simple protocols, such as monitoring the site at dusk, or one illustration: https://www.parks.ca.gov/pages/734/files/imap%20bats%20protocol%20table%20.pdf, Attachment D. The analysis is inadequate as it simply asserts the lack of presence, with theoretical support from a single apparently day time observation, by a 'biologist' of unknown qualifications.

In regards to Comment S-8 and S-21, requesting protocol level surveys, these would be determinative if completed by a qualified biologist, however, the DEIR chose not to apply that standard practice to identify the severity and extent of environmental impacts from the project on special status species, and instead defers that fieldwork to just certain plant and then just for a pre-construction survey. Therefore there is no CEQA analysis on the impact and their severity, or their cumulative impacts, as there is not information about their actual presence or absence.

Issue 5. The new biological information provided in the FEIR is "significant new information".

Section 15088.5 defines as a new significant information as inclusive of a new significant environmental impact, and/or a substantial increase in the severity of an impact. As described above, the failure to analyze the 7 special status plant species would be reasonably considered a significant new impact, and certainly in aggregate a substantially significant increase in severity. Moreover, as identified above, their exclusion from analysis can specifically avoid review by USFWS and CDFW, and are not included in the Protocol surveys regardless.

As identified above, the material defects identified in the FEIR are prejudicial. Regardless of the ultimate substance of the 3-year old revisions to Appendix E, the analysis still missed obvious potential project impacts to special status species and sensitive natural communities. The associated pre-project surveys are of the wrong kind, focused on the redacted list of plant species, and thus specifically unable to detect impacts to species not targeted in the FEIR, and there is no requirement to provide the preconstruction survey during the appropriate time of year to make the detections of even the identified species. Similarly the mitigation is defective since it provides no guarantee that the restoration of habitat will be of 'superior or comparably quality'.

Attachments: A through E

ATTACHMENT A

California Sensitive Natural Communities

Friday, November 8, 2019

This document provides the current list of Sensitive Natural Communities. State and Global rarity ranks are indicated for Alliance and some Associations. Natural Communities with ranks of 1-3 are considered Sensitive. Unranked Associations considered Sensitive are marked with a Y in the rightmost column. A "?" indicates our best estimate of the rank when we know we have insufficient samples over the full expected range of the type, but existing information points to this rank. Pending additions can be found at the bottom of the full Natural Community list. For more information, or to check for updates, please see:

https://www.wildlife.ca.gov/Data/VegCAMP/Natural-Communities

California Natural Community List

Primary Life form: Tree

CaCode	Name	Rarity		Sensitive
Abies amabilis				**Alliance**
88.800.00	**Pacific silver fir forest**	**G5**	**S1**	
88.800.01	*Abies amabilis*			Y
Abies bracteata				**Alliance**
88.300.00	**Santa Lucia fir groves**	**G3**	**S3**	
88.300.01	*Abies bracteata / Galium clementis*			Y
88.300.02	*Abies bracteata / Polystichum munitum*			Y
Abies concolor				**Alliance**
88.500.00	**White fir forest**	**G4**	**S4**	
88.500.11	*Abies concolor / Chimaphila umbellata*	G3?		Y
88.500.37	*Abies concolor – Chrysolepis chrysophylla*			Y
88.500.67	*Abies concolor / Ceanothus prostratus*			Y
Abies concolor – Pinus lambertiana				**Alliance**
88.510.00	**White fir – sugar pine forest**	**G4**	**S4**	
88.510.01	*Abies concolor – Pinus lambertiana*	G3	S3	Y
88.510.03	*Abies concolor – Pinus lambertiana / Maianthemum racemosum – Prosartes hookeri*	G3?		Y
88.510.05	*Abies concolor – Pinus lambertiana – Calocedrus decurrens / Cornus nuttallii / Corylus cornuta*	G3		Y
88.510.07	*Abies concolor – Pinus lambertiana – Calocedrus decurrens / Chrysolepis sempervirens*	G3?		Y
Abies concolor – Pseudotsuga menziesii				**Alliance**
88.530.00	**White fir – Douglas fir forest**	**G5**	**S4**	
88.530.06	*Abies concolor – Pseudotsuga menziesii – (Quercus chrysolepis)*			Y
88.530.15	*Abies concolor – Pseudotsuga menziesii / Corylus cornuta*			Y
88.530.21	*Abies concolor – Pseudotsuga menziesii / Rhododendron macrophyllum – Quercus sadleriana*			Y
88.530.25	*Abies concolor – Pseudotsuga menziesii / Rosa gymnocarpa / Linnaea borealis*			Y
88.530.26	*Abies concolor – Pseudotsuga menziesii / Rubus parviflorus*			Y
88.530.30	*Abies concolor – Pseudotsuga menziesii – Calocedrus decurrens*	G3?		Y
Abies concolor Dry				**Alliance**
88.501.00	**Dry White Fir forest**	**G5**	**S3**	
Abies grandis				**Alliance**
88.100.00	**Grand fir forest**	**G4**	**S2**	

Primary Life form: Tree

CaCode	Name	Rarity		Sensitive
88.100.01	*Abies grandis – Picea sitchensis / Gaultheria shallon / Polystichum munitum*	G1	S1	Y
88.100.02	*Abies grandis – Tsuga heterophylla / Polystichum munitum*	G2	S1	Y
Abies lasiocarpa				**Alliance**
88.400.00	**Subalpine fir forest**	**G5**	**S2**	
88.400.01	*Abies lasiocarpa*			Y
Abies magnifica				**Alliance**
88.200.00	**Red fir forest**	**G5**	**S4**	
88.200.02	*Abies magnifica / Vaccinium membranaceum*			Y
88.200.04	*Abies magnifica / Arctostaphylos nevadensis*	G3	S3	Y
88.200.10	*Abies magnifica – (Calocedrus decurrens)*			Y
88.200.12	*Abies magnifica / Rhododendron macrophyllum*			Y
88.200.26	*Abies magnifica / Wyethia mollis*	G3?		Y
88.200.28	*Abies magnifica – Pinus monticola / Arctostaphylos nevadensis*	G3	S3	Y
88.200.29	*Abies magnifica – Pinus monticola – Pinus contorta ssp. murrayana*	G3	S3	Y
88.200.30	*Abies magnifica – Pinus monticola*	G3	S3	Y
88.200.31	*Abies magnifica – Pinus monticola / Chrysolepis sempervirens*	G3	S3	Y
Abies magnifica – Abies concolor				**Alliance**
88.520.00	**Red fir – white fir forest**	**G5**	**S4**	
88.520.01	*Abies magnifica – Abies concolor*	G3	S3	Y
88.520.09	*Abies magnifica – Abies concolor – Pinus jeffreyi*	G3	S3	Y
Acer macrophyllum				**Alliance**
61.450.00	**Bigleaf maple forest**	**G4**	**S3**	
61.450.01	*Acer macrophyllum*			Y
61.450.02	*Acer macrophyllum – Pseudotsuga menziesii / Adenocaulon bicolor*			Y
61.450.03	*Acer macrophyllum – Pseudotsuga menziesii / Dryopteris arguta*			Y
61.450.04	*Acer macrophyllum – Pseudotsuga menziesii / Corylus cornuta*			Y
61.450.05	*Acer macrophyllum – Pseudotsuga menziesii / Philadelphus lewisii*			Y
61.450.06	*Acer macrophyllum – Pseudotsuga menziesii / Polystichum munitum*			Y
Acer negundo				**Alliance**
61.440.00	**Box-elder forest**	**G5**	**S2**	
61.440.01	*Acer negundo – Salix gooddingii*			Y
61.440.02	*Acer negundo*			Y
Aesculus californica				**Alliance**
75.100.00	**California buckeye groves**	**G3**	**S3**	
75.100.01	*Aesculus californica / Toxicodendron diversilobum / moss*			Y
75.100.02	*Aesculus californica – Umbellularia californica / Diplacus aurantiacus*	G3	S3?	Y
75.100.03	*Aesculus californica*			Y
75.100.04	*Aesculus californica / Datisca glomerata*			Y
75.100.05	*Aesculus californica / Lupinus albifrons*			Y
75.100.06	*Aesculus californica – Umbellularia californica / Holodiscus discolor*			Y
Alnus rhombifolia				**Alliance**
61.420.00	**White alder groves**	**G4**	**S4**	
61.420.01	*Alnus rhombifolia / Polypodium californicum*			Y

Primary Life form: Tree

CaCode	Name	Rarity		Sensitive
61.420.05	*Alnus rhombifolia / Darmera peltata*			Y
61.420.07	*Alnus rhombifolia / Cornus sericea*			Y
61.420.10	*Alnus rhombifolia*	G2Q		Y
61.420.11	*Alnus rhombifolia – Platanus racemosa*	G3	S3	Y
61.420.13	*Alnus rhombifolia – Salix laevigata*			Y
61.420.15	*Alnus rhombifolia – Platanus racemosa – Salix laevigata*			Y
61.420.17	*Alnus rhombifolia / Rhododendron occidentale*			Y
61.420.18	*Alnus rhombifolia / Salix exigua – (Rosa californica)*			Y
Alnus rubra				**Alliance**
61.410.00	**Red alder forest**	**G5**	**S4**	
61.410.01	*Alnus rubra – Pseudotsuga menziesii / Acer circinatum / Claytonia sibirica*			Y
61.410.02	*Alnus rubra / Gaultheria shallon*			Y
61.410.05	*Alnus rubra / Salix lasiolepis*	G4	S3	Y
61.410.06	*Alnus rubra / Rubus spectabilis – Sambucus racemosa*	G3G4		Y
61.410.09	*Alnus rubra / Rubus spp.*			Y
Arbutus menziesii				**Alliance**
73.200.00	**Madrone forest**	**G4**	**S3**	
73.200.01	*Arbutus menziesii – Umbellularia californica – (Notholithocarpus densiflorus)*	G3	S3?	Y
73.200.02	*Arbutus menziesii – Umbellularia californica – Quercus kelloggii*	G3	S3?	Y
73.200.03	*Arbutus menziesii – Quercus agrifolia*	G3	S3?	Y
73.200.04	*Arbutus menziesii – Umbellularia californica*			Y
Bursera microphylla				**Special Stands**
33.120.00	**Elephant tree stands**	**G4**	**S1**	
Callitropsis nootkatensis				**Alliance**
81.200.00	**Alaska yellow-cedar stands**	**G4**	**S1**	
81.200.01	*Callitropsis nootkatensis Subalpine Parkland*	G3	S1	Y
Calocedrus decurrens				**Alliance**
85.100.00	**Incense cedar forest**	**G4**	**S3**	
85.100.01	*Calocedrus decurrens / Listera convallarioides*			Y
85.100.03	*Calocedrus decurrens – Alnus rhombifolia*	G3?		Y
85.100.04	*Calocedrus decurrens – Quercus chrysolepis – Quercus kelloggii*			Y
85.100.05	*Calocedrus decurrens – Abies concolor / Senecio triangularis*			Y
Chamaecyparis lawsoniana				**Alliance**
81.100.00	**Port Orford cedar forest**	**G3**	**S3**	
81.100.01	*Chamaecyparis lawsoniana / Rhododendron occidentale*	G1		Y
81.100.02	*Chamaecyparis lawsoniana – Pseudotsuga menziesii / Quercus vacciniifolia*			Y
81.100.03	*Chamaecyparis lawsoniana – Abies procera / Quercus sadleriana – Vaccinium membranaceum*			Y
81.100.04	*Chamaecyparis lawsoniana / Rhododendron macrophyllum – Gaultheria shallon*			Y
81.100.05	*Chamaecyparis lawsoniana / Gaultheria shallon*			Y
81.100.06	*Chamaecyparis lawsoniana – Abies concolor / Rhododendron occidentale*			Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
81.100.07	*Chamaecyparis lawsoniana – Abies concolor / Quercus sadleriana*				Y
81.100.08	*Chamaecyparis lawsoniana – Abies concolor / herb*				Y
81.100.09	*Chamaecyparis lawsoniana – Abies concolor / Quercus vacciniifolia*				Y
81.100.10	*Chamaecyparis lawsoniana – Pinus monticola / Quercus vacciniifolia*				Y
81.100.11	*Chamaecyparis lawsoniana / Rhododendron occidentale – Notholithocarpus densiflorus var. echinoides*				Y
81.100.12	*Chamaecyparis lawsoniana / Quercus vacciniifolia – Rhododendron occidentale*				Y
81.100.14	*Chamaecyparis lawsoniana – Abies concolor / Chrysolepis sempervirens – (Rhododendron occidentale – Leucothoe davisiae)*				Y
81.100.15	*Chamaecyparis lawsoniana – Pinus monticola / Rhododendron columbianum / Darlingtonia californica*				Y
81.100.16	*Chamaecyparis lawsoniana – Pinus monticola / Alnus viridis*				Y
81.100.17	*Chamaecyparis lawsoniana – Pinus monticola / Vaccinium membranaceum*				Y
81.100.18	*Chamaecyparis lawsoniana – Pinus monticola / wet herb complex*				Y
81.100.19	*Chamaecyparis lawsoniana – Pinus monticola / dry herb complex*	Provisional			Y
81.100.20	*Chamaecyparis lawsoniana – Tsuga heterophylla / Chrysolepis sempervirens*				Y
81.100.21	*Chamaecyparis lawsoniana – Tsuga heterophylla / Rhododendron columbianum*				Y
81.100.22	*Chamaecyparis lawsoniana – Pseudotsuga menziesii / Calycanthus occidentalis*				Y
81.100.24	*Chamaecyparis lawsoniana – Tsuga heterophylla / Leucothoe davisiae*				Y
81.100.25	*Chamaecyparis lawsoniana – Pseudotsuga menziesii – Notholithocarpus densiflorus / Quercus vacciniifolia*				Y
81.100.26	*Chamaecyparis lawsoniana – Pseudotsuga menziesii – Notholithocarpus densiflorus / Rhododendron macrophyllum*				Y
81.100.30	*Chamaecyparis lawsoniana – Abies concolor / Alnus viridis*				Y
81.100.31	*Chamaecyparis lawsoniana – Abies concolor / Acer circinatum*				Y
81.100.32	*Chamaecyparis lawsoniana – Abies ×shastensis – Picea breweriana / Quercus sadleriana – Quercus vacciniifolia*				Y
81.100.33	*Chamaecyparis lawsoniana – Abies ×shastensis / Alnus viridis – Quercus sadleriana*				Y
81.100.34	*Chamaecyparis lawsoniana – Abies ×shastensis / Alnus viridis / Darlingtonia californica*	Provisional			Y
81.100.35	*Chamaecyparis lawsoniana – Pseudotsuga menziesii / Corylus cornuta var. californica*				Y
81.100.36	*Chamaecyparis lawsoniana – Pseudotsuga menziesii – Alnus rubra / Acer circinatum – Mahonia nervosa*				Y
81.100.37	*Chamaecyparis lawsoniana – Pinus monticola / Rhododendron occidentale – Notholithocarpus densiflorus var. echinoides – Rhododendron columbianum*				Y
81.100.39	*Chamaecyparis lawsoniana – Calocedrus decurrens – Alnus rhombifolia*				Y
81.100.40	*Chamaecyparis lawsoniana – Calocedrus decurrens / Quercus vacciniifolia*				Y
Chilopsis linearis – Psorothamnus spinosus					**Alliance**
61.555.00	**Desert-willow – smoketree wash woodland**		**G4**	**S3**	
61.550.01	*Chilopsis linearis*		G3	S3	Y
61.550.02	*Chilopsis linearis / Ambrosia salsola*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
61.550.04	*Chilopsis linearis / Prunus fasciculata*				Y
61.550.05	*Chilopsis linearis / (Ambrosia eriocentra – Salvia dorrii)*				Y
61.550.07	*Chilopsis linearis / Ericameria paniculata*				Y
61.550.08	*Chilopsis linearis / Atriplex polycarpa*				Y
61.570.01	*Psorothamnus spinosus*		G4G5		Y
61.570.02	*Psorothamnus spinosus / Ambrosia salsola – (Bebbia juncea – Ephedra californica)*				Y
61.570.04	*Psorothamnus spinosus /Senegalia greggii – (Hyptis emoryi)*		G4	S3	Y
Fraxinus latifolia					**Alliance**
61.960.00	**Oregon ash groves**		**G4**	**S3**	
61.960.02	*Fraxinus latifolia – Alnus rhombifolia*				Y
61.960.03	*Fraxinus latifolia / Cornus sericea*				Y
61.960.04	*Fraxinus latifolia*				Y
Hesperocyparis abramsiana					**Special Stands**
81.606.00	**Santa Cruz cypress groves**		**G1**	**S1**	
Hesperocyparis bakeri					**Alliance**
81.601.00	**Baker cypress stands**		**G2**	**S2**	
81.601.01	*Hesperocyparis bakeri / Arctostaphylos patula*				Y
Hesperocyparis forbesii					**Alliance**
81.607.00	**Tecate cypress stands**		**G2**	**S2**	
81.607.01	*Hesperocyparis forbesii*	Provisional			Y
Hesperocyparis goveniana					**Special Stands**
81.603.00	**Monterey pygmy cypress stands**		**G1**	**S1**	
Hesperocyparis macnabiana					**Alliance**
81.300.00	**McNab cypress woodland**		**G3**	**S3**	
81.300.02	*Hesperocyparis macnabiana / Arctostaphylos viscida*				Y
Hesperocyparis macrocarpa					**Special Stands**
81.604.00	**Monterey cypress stands**		**G1**	**S1**	
81.604.01	*Hesperocyparis macrocarpa*	Provisional	SNA	GNA	N
Hesperocyparis nevadensis					**Alliance**
81.605.00	**Piute cypress woodland**		**G2**	**S2**	
81.605.01	*Hesperocyparis nevadensis*				Y
Hesperocyparis pigmaea					**Alliance**
81.400.00	**Mendocino pygmy cypress woodland**		**G1**	**S1**	
81.400.06	*Hesperocyparis pigmaea – Pinus contorta ssp. bolanderi – Pinus muricata / Rhododendron macrophyllum*				Y
81.400.07	*Hesperocyparis pigmaea – Pinus contorta ssp. bolanderi / Rhododendron columbianum*				Y
81.400.08	*Hesperocyparis pigmaea – Pinus muricata / Arctostaphylos nummularia*				Y
Hesperocyparis sargentii					**Alliance**
81.500.00	**Sargent cypress woodland**		**G3**	**S3**	

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
81.500.01	*Hesperocyparis sargentii*		G2		Y
81.500.02	*Hesperocyparis sargentii / riparian*		G2?	S2	Y
81.500.03	*Hesperocyparis sargentii / Arctostaphylos montana*		G1	S1.2	Y
81.500.04	*Hesperocyparis sargentii / Ceanothus jepsonii – Arctostaphylos spp.*	Provisional			Y
81.500.05	*Hesperocyparis sargentii / Quercus durata (Mesic)*				Y
Hesperocyparis stephensonii					**Special Stands**
81.610.00	**Cuyamaca cypress stands**		**G1**	**S1**	
Juglans californica					**Alliance**
72.100.00	**California walnut groves**		**G3**	**S3**	
72.100.03	*Juglans californica / annual herbaceous*		G3	S3	Y
72.100.04	*Juglans californica / Artemisia californica / Leymus condensatus*		G3	S3	Y
72.100.05	*Juglans californica / Ceanothus spinosus*		G3	S3	Y
72.100.06	*Juglans californica / Heteromeles arbutifolia*		G3	S3	Y
72.100.07	*Juglans californica / Malosma laurina*		GNR		Y
72.100.08	*Juglans californica – Quercus agrifolia*				Y
Juglans hindsii and Hybrids					**Special Stands and Semi-Natural Alliance**
61.810.00	**Hinds's walnut and related stands**		**G1**	**S1**	
61.810.01	*Juglans hindsii / Sambucus nigra*	Provisional			Y
61.810.02	*Juglans hindsii*				Y
Juniperus californica					**Alliance**
89.100.00	**California juniper woodland**		**G4**	**S4**	
89.100.01	*Juniperus californica / Adenostoma fasciculatum – Eriogonum fasciculatum*				Y
89.100.02	*Juniperus californica / Ericameria linearifolia / annual – perennial herb*				Y
89.100.04	*Juniperus californica / Coleogyne ramosissima*		G3	S3.2	Y
89.100.05	*Juniperus californica / Quercus cornelius-mulleri – Coleogyne ramosissima*		G3	S3.1	Y
89.100.08	*Juniperus californica / Yucca schidigera / Pleuraphis rigida*		G3	S3	Y
89.100.14	*Juniperus californica / Fraxinus dipetala – Ericameria linearifolia*		G3	S3	Y
89.100.15	*Juniperus californica / annual herbaceous*				Y
89.100.19	*Juniperus californica / Salvia leucophylla*				Y
Juniperus grandis					**Alliance**
89.200.00	**Mountain juniper woodland**		**G4**	**S4**	
89.200.02	*Juniperus grandis / Artemisia tridentata*		G3?		Y
89.200.03	*Juniperus grandis – Cercocarpus ledifolius / Artemisia tridentata*		G3?		Y
Juniperus osteosperma					**Alliance**
89.300.00	**Utah juniper woodland**		**G5**	**S3**	
89.300.01	*Juniperus osteosperma*		G5		Y
89.300.05	*Juniperus osteosperma – Yucca brevifolia / Bouteloua eriopoda*				Y
89.300.06	*Juniperus osteosperma / Atriplex confertifolia – (Tetradymia axillaris)*				Y
89.300.07	*Juniperus osteosperma / Ambrosia dumosa*				Y
89.300.08	*Juniperus osteosperma / Coleogyne ramosissima*		GNR		Y
89.300.11	*Juniperus osteosperma / Ephedra nevadensis / Achnatherum speciosum*				Y

Primary Life form: Tree

CaCode	Name	Rarity		Sensitive
89.300.12	*Juniperus osteosperma / Artemisia tridentata ssp. tridentata*			Y
89.300.13	*Juniperus osteosperma / Eriogonum fasciculatum – Yucca baccata*			Y
Notholithocarpus densiflorus				**Alliance**
73.100.00	**Tanoak forest**	**G4**	**S3**	
73.100.01	*Notholithocarpus densiflorus – Pinus lambertiana / Toxicodendron diversilobum*			Y
73.100.02	*Notholithocarpus densiflorus / Frangula californica*			Y
73.100.03	*Notholithocarpus densiflorus – Arbutus menziesii*	G3	S3	Y
73.100.04	*Notholithocarpus densiflorus / Corylus cornuta*			Y
73.100.05	*Notholithocarpus densiflorus / Gaultheria shallon*			Y
73.100.06	*Notholithocarpus densiflorus / Mahonia nervosa*			Y
73.100.07	*Notholithocarpus densiflorus / Quercus vacciniifolia – Rhododendron macrophyllum*			Y
73.100.08	*Notholithocarpus densiflorus / Toxicodendron diversilobum – Lonicera hispidula var. vacillans*			Y
73.100.09	*Notholithocarpus densiflorus / Vaccinium ovatum*			Y
73.100.10	*Notholithocarpus densiflorus – Acer circinatum*			Y
73.100.11	*Notholithocarpus densiflorus – Acer macrophyllum*			Y
73.100.12	*Notholithocarpus densiflorus – Calocedrus decurrens / Festuca californica*			Y
73.100.13	*Notholithocarpus densiflorus – Chamaecyparis lawsoniana*			Y
73.100.14	*Notholithocarpus densiflorus – Chrysolepis chrysophylla*			Y
73.100.15	*Notholithocarpus densiflorus – Cornus nuttallii*			Y
73.100.16	*Notholithocarpus densiflorus – Cornus nuttallii / Toxicodendron diversilobum*			Y
73.100.17	*Notholithocarpus densiflorus – Quercus chrysolepis*			Y
73.100.18	*Notholithocarpus densiflorus – Quercus kelloggii*			Y
73.100.19	*Notholithocarpus densiflorus – Umbellularia californica*			Y
73.100.20	*Notholithocarpus densiflorus – Arbutus menziesii / Ceanothus integerrimus*			Y
73.100.21	*Notholithocarpus densiflorus*			Y
Parkinsonia florida – Olneya tesota				**Alliance**
61.545.00	**Blue palo verde – ironwood woodland**	**G4**	**S4**	
61.545.01	*Olneya tesota*			Y
61.545.02	*Olneya tesota – Psorothamnus schottii*			Y
61.545.03	*Olneya tesota / Larrea tridentata – Encelia farinosa*			Y
61.545.04	*Olneya tesota / Hyptis emoryi*	G4	S3	Y
61.545.05	*Parkinsonia florida*			Y
61.545.06	*Parkinsonia florida – Senegalia greggii – Encelia frutescens*			Y
61.545.07	*Parkinsonia florida / Chilopsis linearis*	G3	S3	Y
61.545.08	*Parkinsonia florida / Hyptis emoryi*	G4	S3	Y
61.545.09	*Parkinsonia florida / Larrea tridentata – Peucephyllum schottii*			Y
61.545.10	*Parkinsonia florida – Olneya tesota*			Y
61.545.11	*Parkinsonia florida – Olneya tesota / Hyptis emoryi*			Y
61.545.12	*Parkinsonia florida – Olneya tesota / Cylindropuntia munzii*			Y
Picea breweriana				**Alliance**
83.300.00	**Brewer spruce forest**	**G3**	**S2**	

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
83.300.03	*Picea breweriana – Abies concolor / Chimaphila umbellata – Pyrola picta*				Y
Picea engelmannii					**Alliance**
83.100.00	**Engelmann spruce forest**		**G5**	**S2**	
83.100.01	*Picea engelmannii / Clintonia uniflora*		G3	S1	Y
83.100.02	*Picea engelmannii / Senecio triangularis*		G3	S1	Y
Picea sitchensis					**Alliance**
83.200.00	**Sitka spruce forest**		**G5**	**S2**	
83.200.01	*Picea sitchensis / Maianthemum dilatatum*				Y
83.200.02	*Picea sitchensis / Rubus spectabilis*		G3		Y
83.200.03	*Picea sitchensis / Polystichum munitum*		G4?		Y
83.200.04	*Picea sitchensis – Tsuga heterophylla*				Y
Pinus albicaulis					**Alliance**
87.180.00	**Whitebark pine forest**		**G5**	**S4**	
87.180.06	*Pinus albicaulis / Penstemon davidsonii*		G3G4		Y
87.180.07	*Pinus albicaulis – Tsuga mertensiana*		G3G4		Y
87.180.08	*Pinus albicaulis / Carex filifolia*		G3G4		Y
87.180.09	*Pinus albicaulis / Carex rossii*		G3?		Y
87.180.10	*Pinus albicaulis / Artemisia tridentata ssp. vaseyana*				Y
Pinus attenuata					**Alliance**
87.100.00	**Knobcone pine forest**		**G4**	**S4**	
87.100.05	*Pinus attenuata / Arctostaphylos viscida*		G3		Y
87.100.09	*Pinus attenuata / Arctostaphylos (manzanita, canescens)*	Provisional			y
Pinus balfouriana					**Alliance**
87.150.00	**Foxtail pine woodland**		**G3**	**S3**	
87.150.01	*Pinus balfouriana*				Y
87.150.02	*Pinus balfouriana / Anemone drummondii*				Y
87.150.03	*Pinus balfouriana / Chrysolepis sempervirens*				Y
87.150.04	*Pinus balfouriana – Abies magnifica*				Y
87.150.05	*Pinus balfouriana – Pinus albicaulis*				Y
87.150.06	*Pinus balfouriana – Pinus monticola*				Y
87.150.07	*Pinus balfouriana – Pinus flexilis*				Y
Pinus contorta ssp. contorta					**Alliance**
87.060.00	**Beach pine forest**		**G5**	**S3**	
87.060.01	*Pinus contorta ssp. contorta*				Y
87.060.02	*Pinus contorta ssp. contorta – Picea sitchensis*				Y
Pinus contorta ssp. murrayana					**Alliance**
87.080.00	**Lodgepole pine forest**		**G4**	**S4**	
87.080.02	*Pinus contorta ssp. murrayana / Artemisia tridentata*		G3?		Y
87.080.06	*Pinus contorta ssp. murrayana / Carex rossii*		G3?		Y
87.080.09	*Pinus contorta ssp. murrayana / Vaccinium uliginosum*		G3	S3?	Y
87.080.12	*Pinus contorta ssp. murrayana / Penstemon newberryi*		G3?		Y

Primary Life form: Tree

CaCode	Name	Rarity		Sensitive
Pinus coulteri				**Alliance**
87.090.00	**Coulter pine woodland**	**G4**	**S4**	
87.090.01	*Pinus coulteri – Calocedrus decurrens – Pinus jeffreyi / Quercus durata*	G2	S2	Y
87.090.02	*Pinus coulteri – Calocedrus decurrens / Quercus durata – Arctostaphylos glauca*	G3	S3	Y
87.090.03	*Pinus coulteri – Pinus sabiniana / Quercus durata – Arctostaphylos pungens*	G3	S3	Y
87.090.06	*Pinus coulteri – Quercus chrysolepis / Arctostaphylos pringlei*			Y
87.092.02	*Pinus coulteri / Arctostaphylos glauca*	G3	S3	Y
87.092.03	*Pinus coulteri – Calocedrus decurrens / Frangula californica ssp. tomentella / Aquilegia eximia*	G2	S2	Y
87.092.04	*Pinus coulteri / Quercus durata*	G3	S3	Y
Pinus edulis				**Alliance**
87.050.00	**Two-needle pinyon stands**	**G4**	**S2?**	
87.050.01	*Pinus edulis – Juniperus osteosperma / Quercus turbinella*			Y
Pinus flexilis				**Alliance**
87.160.00	**Limber pine woodland**	**G5**	**S3**	
87.160.01	*Pinus flexilis / Cercocarpus ledifolius*	G4		Y
87.160.02	*Pinus flexilis – Pinus contorta / Chrysolepis sempervirens*			Y
87.160.03	*Pinus flexilis – Pinus contorta ssp. murrayana*			Y
87.160.04	*Pinus flexilis / Artemisia tridentata*			Y
Pinus jeffreyi				**Alliance**
87.020.00	**Jeffrey pine forest**	**G4**	**S4**	
87.020.02	*Pinus jeffreyi – Pseudotsuga menziesii / Quercus vacciniifolia / Festuca californica*			Y
87.020.03	*Pinus jeffreyi / Festuca idahoensis*			Y
87.020.10	*Pinus jeffreyi / Ceanothus cordulatus*	G3?		Y
87.020.12	*Pinus jeffreyi / Purshia tridentata var. tridentata / Wyethia mollis*			Y
87.020.13	*Pinus jeffreyi / Purshia tridentata var. tridentata / Cercocarpus ledifolius / Achnatherum occidentale*			Y
87.020.14	*Pinus jeffreyi / Purshia tridentata var. tridentata – Symphoricarpos longiflorus / Poa wheeleri*			Y
87.020.15	*Pinus jeffreyi – Quercus kelloggii / Poa secunda*			Y
87.020.16	*Pinus jeffreyi – Quercus kelloggii / Rhus trilobata*			Y
87.020.17	*Pinus jeffreyi / Cercocarpus ledifolius*	GNR		Y
87.020.18	*Pinus jeffreyi / Symphoricarpos longiflorus / Poa wheeleri*			Y
87.020.19	*Pinus jeffreyi / Artemisia tridentata ssp. vaseyana / Festuca idahoensis*			Y
87.020.20	*Pinus jeffreyi / Chrysolepis sempervirens*	G3?		Y
87.020.21	*Pinus jeffreyi / Purshia tridentata var. tridentata*	G3G4		Y
87.020.22	*Pinus jeffreyi / Ericameria ophitidis*			Y
87.020.23	*Pinus jeffreyi / Calamagrostis koelerioides*			Y
87.020.39	*Pinus jeffreyi – Abies magnifica*	G3?		Y
87.020.40	*Pinus jeffreyi – Abies concolor / Festuca californica*			Y
87.200.03	*Pinus jeffreyi – Pinus ponderosa / Purshia tridentata var. tridentata / Festuca idahoensis / Granite*			Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
87.200.07	*Pinus jeffreyi – Pinus ponderosa / Symphoricarpos mollis / Wyethia mollis*				Y
87.205.07	*Pinus jeffreyi – Abies concolor / Symphoricarpos rotundifolius / Elymus elymoides*		G3?		Y
Pinus lambertiana					**Alliance**
87.206.00	**Sugar pine forest**		**G4**	**S3**	
87.206.01	*Pinus lambertiana – Chrysolepis chrysophylla / Quercus vacciniifolia – Quercus sadleriana*				Y
87.206.02	*Pinus lambertiana – Pinus contorta ssp contorta / Quercus vacciniifolia – Notholithocarpus densiflorus var. echinoides*				Y
87.206.03	*Pinus lambertiana – Pinus contorta ssp. murrayana / Notholithocarpus densiflorus var. echinoides – Rhododendron macrophyllum*				Y
87.206.04	*Pinus lambertiana – Pinus monticola / Quercus vacciniifolia – Garrya buxifolia*				Y
Pinus longaeva					**Alliance**
87.140.00	**Bristlecone pine woodland**		**G4**	**S2**	
87.140.01	*Pinus longaeva*		GNR		Y
87.140.02	*Pinus longaeva / Cercocarpus intricatus*				Y
87.140.03	*Pinus longaeva / (Ericameria discoidea, Ribes spp.)*				Y
Pinus monophylla – (Juniperus osteosperma)					**Alliance**
87.040.00	**Singleleaf pinyon – Utah juniper woodlands**		**G5**	**S4**	
87.040.19	*Pinus monophylla – (Juniperus osteosperma) / Quercus turbinella*				Y
87.040.20	*Pinus monophylla – Juniperus osteosperma / Coleogyne ramosissima*				Y
87.040.22	*Pinus monophylla / Eriogonum fasciculatum*				Y
87.040.23	*Pinus monophylla / Quercus john-tuckeri*	Provisional			Y
Pinus monticola					**Alliance**
87.170.00	**Western white pine forest**		**G5**	**S4**	
87.170.01	*Pinus monticola – Pinus contorta ssp. murrayana / Notholithocarpus densiflorus var. echinoides*				Y
87.170.02	*Pinus monticola / Holodiscus discolor*				Y
87.170.03	*Pinus monticola / Xerophyllum tenax*				Y
87.170.04	*Pinus monticola / Angelica arguta*				Y
Pinus muricata – Pinus radiata					**Alliance**
87.240.00	**Bishop pine – Monterey pine forest**		**G3**	**S3**	
87.070.01	*Pinus muricata – (Arbutus menziesii) / Vaccinium ovatum*		G2	S2	Y
87.070.04	*Pinus muricata – Pseudotsuga menziesii*				Y
87.070.07	*Pinus muricata / Arctostaphylos glandulosa*		G2	S2	Y
87.070.09	*Pinus muricata / Xerophyllum tenax*				Y
87.070.11	*Pinus muricata – Chrysolepis chrysophylla / Arctostaphylos nummularia*		G2	S2	Y
87.070.12	*Pinus muricata – Notholithocarpus densiflorus*	Provisional	G3	S3	Y
87.110.01	*Pinus radiata / Arctostaphylos tomentosa – Vaccinium ovatum*				Y
87.110.02	*Pinus radiata / Toxicodendron diversilobum*				Y
87.110.03	*Pinus radiata – Pinus muricata / Arctostaphylos tomentosa – Arctostaphylos hookeri*				Y
87.110.04	*Pinus radiata – Quercus agrifolia / Toxicodendron diversilobum*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
87.240.01	*Pinus muricata / Comarostaphylis diversifolia ssp. planifolia*	Provisional			Y
87.240.02	*Pinus muricata / Arctostaphylos spp.*	Provisional			Y
87.240.03	*Pinus muricata*	Provisional	G3?	S3?	Y
87.240.04	*Pinus radiata plantations*	Provisional	GNR	SNR	N
Pinus ponderosa					**Alliance**
87.010.00	**Ponderosa pine forest**		**G5**	**S4**	
87.010.02	*Pinus ponderosa / Chamaebatia foliolosa*				Y
87.010.03	*Pinus ponderosa / Arctostaphylos patula – Chamaebatia foliolosa*				Y
87.010.04	*Pinus ponderosa / Artemisia tridentata*		GNR		Y
87.010.05	*Pinus ponderosa / Purshia tridentata var. tridentata*				Y
87.010.06	*Pinus ponderosa / Bromus carinatus*				Y
87.010.07	*Pinus ponderosa / Galium angustifolium*				Y
87.010.08	*Pinus ponderosa / Ceanothus prostratus*				Y
87.010.09	*Pinus ponderosa / Ceanothus cuneatus*				Y
87.010.10	*Pinus ponderosa / Purshia tridentata var. tridentata / Balsamorhiza sagittata*				Y
87.010.12	*Pinus ponderosa / Purshia tridentata var. tridentata / Achnatherum nelsonii / pumice*				Y
87.010.13	*Pinus ponderosa / Purshia tridentata var. tridentata – Arctostaphylos patula / Achnatherum nelsonii*				Y
87.010.14	*Pinus ponderosa / Purshia tridentata var. tridentata – Ceanothus velutinus*				Y
87.010.15	*Pinus ponderosa / Purshia tridentata var. tridentata / Senecio integerrimus / granite*				Y
87.010.16	*Pinus ponderosa / Purshia tridentata var. tridentata – Ribes cereum / Bromus orcuttianus*				Y
87.010.18	*Pinus ponderosa / Achnatherum nelsonii*				Y
87.010.19	*Pinus ponderosa / Cercocarpus ledifolius – Purshia tridentata var. tridentata / Festuca idahoensis*				Y
87.010.20	*Pinus ponderosa / Cercocarpus ledifolius / Pseudoroegneria spicata*				Y
87.010.23	*Pinus ponderosa – Pinus contorta ssp. murrayana / Amelanchier alnifolia*				Y
87.010.24	*Pinus ponderosa / Artemisia tridentata ssp. vaseyana / Festuca idahoensis*				Y
87.010.25	*Pinus ponderosa – Pinus jeffreyi / Artemisia tridentata ssp. vaseyana – Purshia tridentata var. tridentata*				Y
87.010.26	*Pinus ponderosa / Amelanchier alnifolia – Prunus virginiana*				Y
87.010.27	*Pinus ponderosa / Amelanchier alnifolia – Mahonia repens / Arnica cordifolia*				Y
87.010.28	*Pinus ponderosa / Ceanothus velutinus / Achnatherum nelsonii*				Y
87.010.29	*Pinus ponderosa / Symphoricarpos longiflorus*				Y
87.010.56	*Pinus ponderosa / Artemisia tridentata ssp. vaseyana – Purshia tridentata var. tridentata*				Y
87.010.57	*Pinus ponderosa – Pinus jeffreyi / Purshia tridentata var. tridentata / Festuca idahoensis*				Y
Pinus ponderosa – Pseudotsuga menziesii					**Alliance**
82.400.00	**Ponderosa pine – Douglas fir forest**		**G4**	**S4**	
82.400.02	*Pinus ponderosa – Pseudotsuga menziesii – Calocedrus decurrens*		G3?		Y
82.400.03	*Pinus ponderosa – Pseudotsuga menziesii – Pinus jeffreyi / Poa secunda*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
82.400.04	*Pinus ponderosa – Pseudotsuga menziesii*				Y
Pinus ponderosa var. washoensis					**Alliance**
87.120.00	**Washoe pine woodland**		**G2**	**S2**	
87.120.01	*Pinus ponderosa var. washoensis / Lupinus caudatus*				Y
87.120.02	*Pinus ponderosa var. washoensis / Symphoricarpos longiflorus / Pseudostellaria jamesiana*				Y
87.120.03	*Pinus ponderosa var. washoensis / Arctostaphylos nevadensis*				Y
Pinus quadrifolia					**Alliance**
87.030.00	**Parry pinyon woodland**		**G3**	**S2**	
87.030.01	*Pinus quadrifolia / Quercus cornelius-mulleri*				Y
Pinus sabiniana					**Alliance**
87.130.00	**Foothill pine woodland**		**G4**	**S4**	
87.130.02	*Pinus sabiniana – Juniperus californica / grass*		G3	S3	Y
87.130.03	*Pinus sabiniana / Ceanothus cuneatus / Plantago erecta*				Y
87.130.04	*Pinus sabiniana – Quercus wislizeni / Ceanothus cuneatus*		G3?		Y
87.130.14	*Pinus sabiniana / Eriogonum fasciculatum*				Y
87.130.15	*Pinus sabiniana / Cercis occidentalis*				Y
87.130.16	*Pinus sabiniana / herbaceous*	Provisional			Y
87.130.17	*Pinus sabiniana / Quercus durata*	Provisional			Y
Pinus torreyana					**Alliance**
87.190.00	**Torrey pine woodland**		**G1**	**S1**	
87.190.01	*Pinus torreyana / Artemisia californica – Rhus integrifolia*		G1	S1	Y
87.190.02	*Pinus torreyana ssp. insularis*		G1	S1	Y
Platanus racemosa					**Alliance**
61.310.00	**California sycamore woodlands**		**G3**	**S3**	
61.311.01	*Platanus racemosa / Avena barbata*				Y
61.311.02	*Platanus racemosa / Bromus hordeaceus*				Y
61.311.03	*Platanus racemosa / annual grass*		G3	S3	Y
61.312.01	*Platanus racemosa – Quercus agrifolia*		G3	S3	Y
61.312.03	*Platanus racemosa – Quercus agrifolia – Salix lasiolepis*		G3	S3	Y
61.312.04	*Platanus racemosa – Quercus agrifolia / Baccharis salicifolia / Artemisia douglasiana*		G3	S3	Y
61.312.05	*Platanus racemosa – Salix laevigata / Salix lasiolepis – Baccharis salicifolia*				Y
61.312.06	*Platanus racemosa – Quercus agrifolia – Populus fremontii – Salix laevigata*				Y
61.312.07	*Platanus racemosa – Salix laevigata*				Y
61.312.08	*Platanus racemosa – Quercus lobata*				Y
61.313.01	*Platanus racemosa / Baccharis salicifolia*				Y
61.313.02	*Platanus racemosa / Toxicodendron diversilobum*				Y
61.313.03	*Platanus racemosa / Adenostoma fasciculatum*				Y
61.314.01	*Platanus racemosa – Populus fremontii*				Y
61.314.02	*Platanus racemosa – Populus fremontii / Salix lasiolepis – Salix exigua / Schoenoplectus americanus*				Y
61.314.03	*Platanus racemosa – Populus fremontii / Salix lasiolepis*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
Populus fremontii – Fraxinus velutina – Salix gooddingii					**Alliance**
61.130.00	**Fremont cottonwood forest**		**G4**	**S3**	
61.130.06	*Populus fremontii*		G2Q		Y
61.130.07	*Populus fremontii / Acer negundo*		G2Q		Y
61.130.08	*Populus fremontii / Acer negundo / Rubus armeniacus*				Y
61.130.11	*Populus fremontii / Rubus ursinus*				Y
61.130.13	*Populus fremontii / Vitis californica*				Y
61.130.14	*Populus fremontii – Salix gooddingii / Baccharis salicifolia*		G2		Y
61.130.15	*Populus fremontii – Salix laevigata*				Y
61.130.16	*Populus fremontii / Baccharis salicifolia*		G2		Y
61.130.17	*Populus fremontii / Salix exigua*				Y
61.130.18	*Populus fremontii – Juglans californica*				Y
61.130.19	*Populus fremontii – Prosopis spp.*	Provisional			Y
61.130.20	*Populus fremontii – Quercus agrifolia*				Y
61.130.21	*Populus fremontii – Salix laevigata / Salix lasiolepis / Vitis girdiana*				Y
61.130.22	*Populus fremontii – Salix laevigata / Salix lasiolepis – Baccharis salicifolia*				Y
61.130.23	*Populus fremontii – Salix lasiolepis*				Y
61.130.24	*Populus fremontii – Salix (laevigata, lasiolepis, lucida ssp. lasiandra)*				Y
61.130.25	*Populus fremontii – Salix lucida ssp. lasiandra*				Y
61.130.26	*Populus fremontii – Sambucus nigra*				Y
61.130.28	*Populus fremontii Great Valley*				Y
61.130.29	*Populus fremontii / Baccharis (emoryi, salicina)*				Y
61.130.30	*Populus fremontii / Baccharis sergiloides*				Y
61.130.31	*Populus fremontii – Fraxinus velutina*				Y
61.211.04	*Populus fremontii – Salix gooddingii*				Y
Populus tremuloides					**Alliance**
61.111.00	**Aspen groves**		**G5**	**S3**	
61.111.02	*Populus tremuloides*				Y
61.111.03	*Populus tremuloides / Veratrum californicum*		G3?		Y
61.111.04	*Populus tremuloides / upland*				Y
61.111.05	*Populus tremuloides / Symphyotrichum foliaceum*				Y
61.111.06	*Populus tremuloides / Artemisia tridentata*		G3G4		Y
61.111.07	*Populus tremuloides / Artemisia tridentata / Monardella odoratissima – Kelloggia galioides*		GNR		Y
61.111.08	*Populus tremuloides / Monardella odoratissima*		G3		Y
61.111.09	*Populus tremuloides / Pinus jeffreyi*				Y
61.111.10	*Populus tremuloides / Rosa woodsii*		GNR		Y
61.111.11	*Populus tremuloides – Pinus contorta / Artemisia tridentata / Poa pratensis*				Y
61.111.14	*Populus tremuloides / Prunus*				Y
61.111.15	*Populus tremuloides / Symphoricarpos albus*		G3?		Y
61.111.16	*Populus tremuloides / Symphoricarpos rotundifolius*				Y
61.111.17	*Populus tremuloides / mesic forb*				Y
61.111.18	*Populus tremuloides / dry graminoid*				Y
61.111.19	*Populus tremuloides / Bromus carinatus*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
61.111.20	*Populus tremuloides / Poa pratensis*		G1?		Y
Populus trichocarpa					**Alliance**
61.120.00	**Black cottonwood forest**		**G5**	**S3**	
61.120.01	*Populus trichocarpa*				Y
61.120.03	*Populus trichocarpa – Pinus jeffreyi*		G3?		Y
61.120.04	*Populus trichocarpa / Artemisia tridentata ssp. vaseyana*				Y
61.120.05	*Populus trichocarpa / Symphoricarpos rotundifolius*				Y
61.120.06	*Populus spp. / Salix spp.*				Y
61.120.07	*Populus trichocarpa / Rhododendron occidentale*	Provisional			Y
61.120.08	*Populus trichocarpa – Quercus agrifolia*				Y
61.120.09	*Populus trichocarpa – Salix laevigata*				Y
61.120.10	*Populus trichocarpa – Salix lasiolepis*				Y
61.120.11	*Populus trichocarpa – Salix lucida*				Y
Prosopis glandulosa – Prosopis velutina – Prosopis pubescens					**Alliance**
61.514.00	**Mesquite thickets**		**G5**	**S3**	
61.512.01	*Prosopis glandulosa var. torreyana*		GNR		Y
61.512.02	*Prosopis glandulosa – Sambucus nigra*				Y
61.512.06	*Prosopis glandulosa / Pluchea sericea*				Y
61.512.07	*Prosopis glandulosa / Rhus ovata (upper desert spring)*				Y
61.512.09	*Prosopis glandulosa – (Salix exigua – Salix lasiolepis)*				Y
61.513.02	*Prosopis pubescens / Pluchea sericea Alkaline Spring*				Y
61.513.03	*Prosopis / Bebbia juncea – Petalonyx thurberi (wash)*				Y
61.514.01	*Prosopis pubescens / Baccharis sergiloides*				Y
61.514.02	*Prosopis glandulosa / (Atriplex spp. – Suaeda moquinii)*				Y
Pseudotsuga macrocarpa					**Alliance**
82.100.00	**Bigcone Douglas fir forest**		**G3**	**S3**	
82.100.01	*Pseudotsuga macrocarpa – Quercus agrifolia*				Y
82.100.02	*Pseudotsuga macrocarpa – Quercus chrysolepis*				Y
Pseudotsuga menziesii					**Alliance**
82.200.00	**Douglas fir forest**		**G5**	**S4**	
82.200.09	*Pseudotsuga menziesii – Chrysolepis chrysophylla / Xerophyllum tenax*				Y
82.200.10	*Pseudotsuga menziesii – Chrysolepis chrysophylla / Rhododendron macrophyllum – Mahonia nervosa*				Y
82.200.11	*Pseudotsuga menziesii – Chrysolepis chrysophylla / Rhododendron macrophyllum – Quercus sadleriana – Xerophyllum tenax*				Y
82.200.12	*Pseudotsuga menziesii – Chrysolepis chrysophylla – Notholithocarpus densiflorus*		G3	S3	Y
82.200.13	*Pseudotsuga menziesii – Chrysolepis chrysophylla – Notholithocarpus densiflorus / Mahonia nervosa*				Y
82.200.15	*Pseudotsuga menziesii / Quercus vacciniifolia*				Y
82.200.16	*Pseudotsuga menziesii / Quercus vacciniifolia – Notholithocarpus densiflorus var. echinoides*				Y
82.200.19	*Pseudotsuga menziesii – Quercus garryana var. garryana / grass*				Y
82.200.20	*Pseudotsuga menziesii / Acer circinatum – Mahonia nervosa*				Y

Primary Life form: Tree

CaCode	Name	Rarity		Sensitive
82.200.49	*Pseudotsuga menziesii / Achlys triphylla*			Y
82.200.50	*Pseudotsuga menziesii – Arbutus menziesii*			Y
82.200.54	*Pseudotsuga menziesii / Chimaphila umbellata*			Y
82.200.55	*Pseudotsuga menziesii / Linnaea borealis*	G4		Y
82.200.56	*Pseudotsuga menziesii / Corylus cornuta*			Y
82.200.57	*Pseudotsuga menziesii / Vancouveria planipetala*			Y
82.200.58	*Pseudotsuga menziesii / Rhododendron spp.*			Y
82.200.59	*Pseudotsuga menziesii / Gaultheria shallon*	G3G4		Y
82.200.60	*Pseudotsuga menziesii – Quercus kelloggii*			Y
82.200.64	*Pseudotsuga menziesii / Mahonia nervosa*			Y
82.200.66	*Pseudotsuga menziesii – Umbellularia californica*			Y
82.200.71	*Pseudotsuga menziesii – Quercus agrifolia*	G3	S3?	Y
82.200.74	*Pseudotsuga menziesii / Quercus vacciniifolia – Rhododendron macrophyllum*			Y
82.200.83	*Pseudotsuga menziesii – Chrysolepis chrysophylla / Rhododendron macrophyllum – Quercus sadleriana – Gaultheria shallon*			Y
82.200.84	*Pseudotsuga menziesii – Quercus garryana var. garryana / Holodiscus discolor*			Y
82.300.01	*Pseudotsuga menziesii – Quercus chrysolepis – mixed conifer / Polystichum munitum*			Y
82.300.02	*Pseudotsuga menziesii – Quercus chrysolepis – Arbutus menziesii / Toxicodendron diversilobum*			Y
82.300.03	*Pseudotsuga menziesii – Quercus chrysolepis*	G3?	S3?	Y
82.300.05	*Pseudotsuga menziesii – Quercus chrysolepis – Notholithocarpus densiflorus*			Y
Pseudotsuga menziesii – Calocedrus decurrens				**Alliance**
82.600.00	**Douglas fir – incense cedar forest**	**G3**	**S3**	
82.600.01	*Pseudotsuga menziesii – Calocedrus decurrens – Umbellularia californica / Toxicodendron diversilobum*			Y
82.600.02	*Pseudotsuga menziesii – Calocedrus decurrens / Festuca californica*			Y
82.600.04	*Pseudotsuga menziesii – Calocedrus decurrens / Quercus vacciniifolia*			Y
82.600.12	*Pseudotsuga menziesii – Calocedrus decurrens – Pinus jeffreyi*			Y
82.600.13	*Pseudotsuga menziesii – Calocedrus decurrens – Pinus jeffreyi / Festuca californica*			Y
82.600.14	*Pseudotsuga menziesii – Calocedrus decurrens – (Quercus kelloggii) / Nassella pulchra*			Y
82.600.15	*Pseudotsuga menziesii – Calocedrus decurrens – (Pinus jeffreyi) / Nassella pulchra*			Y
Pseudotsuga menziesii – Notholithocarpus densiflorus				**Alliance**
82.500.00	**Douglas fir – tanoak forest**	**G3**	**S3**	
82.200.82	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Aralia californica*			Y
82.500.01	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Chimaphila umbellata*			Y
82.500.03	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Quercus kelloggii) / Rosa gymnocarpa*			Y

Primary Life form: Tree

CaCode	Name	Rarity	Sensitive
82.500.04	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Umbellularia californica) / Toxicodendron diversilobum*		Y
82.500.05	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Quercus chrysolepis, Quercus kelloggii) / Toxicodendron diversilobum*		Y
82.500.06	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Quercus chrysolepis) / Mahonia nervosa – Gaultheria shallon*		Y
82.500.07	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Mahonia nervosa*		Y
82.500.08	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Quercus chrysolepis) / Vaccinium ovatum*		Y
82.500.10	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Quercus chrysolepis) / Toxicodendron diversilobum*		Y
82.500.11	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Quercus chrysolepis) / rockpile*		Y
82.500.12	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chrysolepis chrysophylla) / Pteridium aquilinum*		Y
82.500.13	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Quercus chrysolepis) / Mahonia nervosa*		Y
82.500.15	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chrysolepis chrysophylla) / Rhododendron macrophyllum – Gaultheria shallon*		Y
82.500.16	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chrysolepis chrysophylla) / Gaultheria shallon*		Y
82.500.20	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Vaccinium ovatum – (Gaultheria shallon)*		Y
82.500.21	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Corylus cornuta*		Y
82.500.22	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Calocedrus decurrens) / Festuca californica*		Y
82.500.23	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Toxicodendron diversilobum – (Lonicera hispidula)*		Y
82.500.24	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana – Umbellularia californica) / Vaccinium ovatum*		Y
82.500.25	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana) / Mahonia nervosa / Linnaea borealis*		Y
82.500.26	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana) / Vaccinium ovatum*		Y
82.500.27	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana) / Vaccinium ovatum – Rhododendron occidentale*		Y
82.500.28	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana) / Vaccinium parvifolium*		Y
82.500.29	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana) / Gaultheria shallon*		Y
82.500.30	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana) / Acer circinatum*		Y
82.500.31	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana – Alnus rubra) / riparian*		Y
82.500.35	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Gaultheria shallon*		Y
82.500.36	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Acer circinatum*		Y
82.500.38	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Taxus brevifolia*		Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
82.500.39	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Pinus lambertiana)*				Y
82.500.40	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Achlys triphylla*				Y
82.500.43	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Cornus nuttallii*				Y
82.500.44	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Iris*				Y
82.500.46	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Quercus vacciniifolia – Holodiscus discolor*				Y
82.500.47	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Whipplea modesta*				Y
82.500.48	*Pseudotsuga menziesii – Notholithocarpus densiflorus*				Y
82.500.49	*Pseudotsuga menziesii – Notholithocarpus densiflorus / Rhododendron macrophyllum*		G2	S2	Y
82.500.50	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Acer macrophyllum) / Polystichum munitum*				Y
82.500.51	*Pseudotsuga menziesii – Notholithocarpus densiflorus – Thuja plicata / Vaccinium ovatum – Gaultheria shallon*				Y
82.500.52	*Pseudotsuga menziesii – Notholithocarpus densiflorus – (Chamaecyparis lawsoniana – Tsuga heterophylla) / Vaccinium ovatum*				Y
Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizeni)					**Alliance**
71.100.00	**Mixed oak forest**		**G4**	**S4**	
71.100.15	*Quercus agrifolia – Quercus garryana – Quercus kelloggii*				Y
Quercus agrifolia					**Alliance**
71.060.00	**Coast live oak woodland**		**G5**	**S4**	
71.060.07	*Quercus agrifolia / Adenostoma fasciculatum – (Salvia mellifera)*		G3	S3	Y
71.060.18	*Quercus agrifolia – Quercus kelloggii*				Y
71.060.26	*Quercus agrifolia – Arbutus menziesii – Umbellularia californica*		G3	S3	Y
71.060.27	*Quercus agrifolia – Juglans californica*		G3	S3	Y
71.060.37	*Quercus agrifolia / Quercus (berberidifolia, xacutidens)*		G3	S3	Y
71.060.38	*Quercus agrifolia / Salvia leucophylla – Artemisia californica*		G3	S3	Y
71.060.47	*Quercus agrifolia / Salix lasiolepis*		G3	S3	Y
71.060.48	*Quercus agrifolia – Umbellularia californica*		G3	S3	Y
71.060.49	*Quercus agrifolia – Umbellularia californica / Ceanothus oliganthus*		G3	S3	Y
71.060.53	*Quercus agrifolia – Quercus tomentella / (Prunus ilicifolia ssp. lyonii)*	Provisional			Y
71.060.54	*Quercus agrifolia / Quercus pacifica*				Y
71.060.55	*Quercus agrifolia / Arctostaphylos (insularis)*	Provisional			Y
Quercus chrysolepis (tree)					**Alliance**
71.050.00	**Canyon live oak forest**		**G5**	**S5**	
71.050.02	*Quercus chrysolepis – Pinus lambertiana*				Y
71.050.03	*Quercus chrysolepis / Ceanothus integerrimus*				Y
71.050.07	*Quercus chrysolepis – Quercus garryana var. garryana / Pentagramma triangularis*				Y
71.050.15	*Quercus chrysolepis / Arctostaphylos patula*		G3?		Y
71.050.17	*Quercus chrysolepis / Dryopteris arguta*		G3?		Y
71.050.18	*Quercus chrysolepis – Pinus ponderosa*		G3?		Y
71.050.19	*Quercus chrysolepis – Calocedrus decurrens*		G3?		Y
71.050.27	*Quercus chrysolepis – Quercus kelloggii – Acer macrophyllum*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
71.050.28	*Quercus chrysolepis – Quercus lobata / Vitis californica*				Y
71.050.30	*Quercus chrysolepis – Umbellularia californica / Vitis californica*				Y
71.050.34	*Quercus chrysolepis / Styrax redivivus*				Y
Quercus douglasii					**Alliance**
71.020.00	**Blue oak woodland**		**G4**	**S4**	
71.020.11	*Quercus douglasii – Quercus lobata*				Y
71.020.12	*Quercus douglasii / Ceanothus cuneatus*		G3G4		Y
71.020.14	*Quercus douglasii / Cercocarpus montanus / Bowlesia incana – Lithophragma affine*				Y
71.020.21	*Quercus douglasii / Selaginella hansenii – Navarretia pubescens*				Y
71.020.23	*Quercus douglasii – Juniperus californica / Ceanothus cuneatus*				Y
71.020.41	*Quercus douglasii – Juniperus californica / Quercus john-tuckeri*		G3	S3	Y
71.020.42	*Quercus douglasii – Juniperus californica / Cercocarpus montanus*		G3	S3	Y
71.020.47	*Quercus ×eplingii / Grass*	Provisional			Y
Quercus engelmannii					**Alliance**
71.070.00	**Engelmann oak woodland**		**G3**	**S3**	
71.070.02	*Quercus engelmannii – Quercus agrifolia / Artemisia californica*				Y
71.070.03	*Quercus engelmannii – Quercus agrifolia / chaparral (Adenostoma fasciculatum – Quercus berberidifolia – Rhamnus ilicifolia)*				Y
71.070.04	*Quercus engelmannii – Quercus agrifolia / Toxicodendron diversilobum / annual grass*				Y
71.070.05	*Quercus engelmannii / Adenostoma fasciculatum – Arctostaphylos glauca*				Y
71.070.06	*Quercus engelmannii / annual grass – herb*				Y
71.070.07	*Quercus engelmannii / Quercus berberidifolia*				Y
71.070.08	*Quercus engelmannii / Salvia apiana / grass – herb*				Y
71.070.09	*Quercus engelmannii / Toxicodendron diversilobum / grass*				Y
Quercus garryana (tree)					**Alliance**
71.030.00	**Oregon white oak woodland**		**G4**	**S3**	
71.030.01	*Quercus garryana – Quercus kelloggii / Arrhenatherum elatius*				Y
71.030.02	*Quercus garryana var. garryana – Quercus garryana var. breweri / Festuca californica*				Y
71.030.03	*Quercus garryana – Pseudotsuga menziesii / Festuca californica*				Y
71.030.04	*Quercus garryana / Toxicodendron diversilobum*				Y
71.030.05	*Quercus garryana / Symphoricarpos albus*				Y
71.030.06	*Quercus garryana / Cynosurus cristatus*				Y
71.030.07	*Quercus garryana / Ribes roezlii*				Y
71.030.08	*Quercus garryana / Philadelphus lewisii*				Y
71.030.09	*Quercus garryana / Delphinium trolliifolium*				Y
71.030.10	*Quercus garryana / Dactylis glomerata*				Y
71.030.11	*Quercus garryana / Bromus carinatus*				Y
71.030.13	*Quercus garryana / Melica subulata*				Y
71.030.14	*Quercus garryana – Quercus kelloggii / Toxicodendron diversilobum*				Y
71.030.15	*Quercus garryana – Quercus kelloggii / Dichelostemma ida-maia*				Y
71.030.16	*Quercus garryana – Umbellularia californica – Quercus (agrifolia, kelloggii)*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
71.030.17	*Quercus garryana / (Cynosurus echinatus – Festuca californica)*				Y
Quercus kelloggii					**Alliance**
71.010.00	**California black oak forest**		**G4**	**S4**	
71.010.02	*Quercus kelloggii – Quercus agrifolia – pine / Holodiscus discolor*				Y
71.010.06	*Quercus kelloggii / Arctostaphylos patula*		G3?		Y
71.010.10	*Quercus kelloggii / Toxicodendron diversilobum – Styrax redivivus / Triteleia laxa*				Y
71.010.11	*Quercus kelloggii – Quercus lobata / grass*				Y
71.010.17	*Quercus kelloggii – Pseudotsuga menziesii*				Y
71.010.20	*Quercus kelloggii / Arctostaphylos mewukka / Chamaebatia foliolosa*		G3?		Y
71.010.22	*Quercus kelloggii – Arbutus menziesii – Quercus agrifolia*		G3	S3	Y
71.010.29	*Quercus kelloggii – Pseudotsuga menziesii – Umbellularia californica*				Y
Quercus lobata					**Alliance**
71.040.00	**Valley oak woodland**		**G3**	**S3**	
71.040.05	*Quercus lobata / grass*				Y
71.040.06	*Quercus lobata – Quercus agrifolia / grass*				Y
71.040.09	*Quercus lobata / Rhus trilobata*				Y
71.040.10	*Quercus lobata / Rubus armeniacus*				Y
71.040.11	*Quercus lobata – Alnus rhombifolia*				Y
71.040.12	*Quercus lobata – Quercus wislizeni*				Y
71.040.13	*Quercus lobata / herbaceous semi-riparian*				Y
71.040.14	*Quercus lobata (Sacramento River)*				Y
71.040.15	*Quercus lobata – Acer negundo*				Y
71.040.16	*Quercus lobata – Fraxinus latifolia / Vitis californica*				Y
71.040.17	*Quercus lobata – Quercus agrifolia / Toxicodendron diversilobum*				Y
71.040.18	*Quercus lobata – Quercus douglasii*				Y
71.040.19	*Quercus lobata – Quercus kelloggii*				Y
71.040.20	*Quercus lobata – Salix lasiolepis*		G2	S2?	Y
71.040.21	*Quercus lobata / Carex barbarae*				Y
71.040.22	*Quercus lobata / Rubus ursinus – Rosa californica*				Y
Quercus parvula var. shrevei		**Provisional**			**Alliance**
71.085.00	**Shreve oak forests**		**G2**	**S2**	
Quercus tomentella – Lyonothamnus floribundus					**Alliance**
77.100.00	**Island live oak – Catalina ironwood woodland**		**G3**	**S3**	
77.100.01	*Quercus tomentella*		G2	S2	Y
77.100.02	*Lyonothamnus floribundus*		G2	S2	Y
Quercus wislizeni (tree)					**Alliance**
71.080.00	**Interior live oak woodland**		**G4**	**S4**	
71.080.02	*Quercus wislizeni – Pinus sabiniana / Arctostaphylos manzanita*				Y
71.080.08	*Quercus wislizeni – Pinus sabiniana / Arctostaphylos viscida*		G3?		Y
71.080.13	*Quercus wislizeni – Salix laevigata / Frangula californica*				Y
71.080.15	*Quercus wislizeni – Pinus ponderosa*				Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
Salix gooddingii – Salix laevigata					**Alliance**
61.216.00	**Gooding's willow – red willow riparian woodlands**		**G4**	**S3**	
61.205.01	*Salix laevigata*		GNR		Y
61.205.02	*Salix laevigata / Salix lasiolepis*				Y
61.205.04	*Salix laevigata / Rosa californica*				Y
61.205.05	*Salix laevigata – Cornus sericea / Scirpus microcarpus*		G3	S3?	Y
61.211.01	*Salix gooddingii*				Y
61.211.02	*Salix gooddingii / Baccharis salicifolia*				Y
61.211.03	*Salix gooddingii / Lepidium latifolium*				Y
61.211.05	*Salix gooddingii – Salix laevigata*				Y
61.211.06	*Salix gooddingii – Quercus lobata / wetland herb*				Y
61.211.07	*Salix gooddingii / Rubus armeniacus*				Y
61.211.08	*Salix gooddingii – Salix lucida – Populus fremontii*				Y
61.211.09	*Salix gooddingii / Salix exigua*				Y
61.211.10	*Salix gooddingii – Fraxinus latifolia*	Provisional			Y
Salix lucida ssp. lasiandra					**Alliance**
61.204.00	**Shining willow groves**		**G4**	**S3**	
61.204.01	*Salix lucida ssp. lasiandra / Urtica urens – Urtica dioica*				Y
61.204.03	*Salix lucida ssp. lasiandra*				Y
61.204.04	*Salix lucida ssp. lasiandra / Cornus sericea*				Y
Sequoia sempervirens					**Alliance**
86.100.00	**Redwood forest**		**G3**	**S3**	
86.100.01	*Sequoia sempervirens – Acer macrophyllum / Polypodium californicum*				Y
86.100.02	*Sequoia sempervirens / (Pteridium aquilinum) – Woodwardia fimbriata*		G3	S3	Y
86.100.03	*Sequoia sempervirens / Pteridium aquilinum – Trillium ovatum*				Y
86.100.04	*Sequoia sempervirens*				Y
86.100.05	*Sequoia sempervirens / Marah fabaceus – Vicia sativa ssp. nigra*				Y
86.100.06	*Sequoia sempervirens – Notholithocarpus densiflorus / Carex globosa – Iris douglasiana*				Y
86.100.07	*Sequoia sempervirens / Blechnum spicant*				Y
86.100.08	*Sequoia sempervirens / Mahonia nervosa*				Y
86.100.09	*Sequoia sempervirens – Arbutus menziesii*				Y
86.100.10	*Sequoia sempervirens – Pseudotsuga menziesii – Arbutus menziesii*				Y
86.100.11	*Sequoia sempervirens – Pseudotsuga menziesii / Gaultheria shallon*				Y
86.100.12	*Sequoia sempervirens – Pseudotsuga menziesii / Vaccinium ovatum*				Y
86.100.13	*Sequoia sempervirens / Oxalis oregana*				Y
86.100.14	*Sequoia sempervirens – Acer macrophyllum – Umbellularia californica*		G3	S3	Y
86.100.15	*Sequoia sempervirens – Arbutus menziesii / Vaccinium ovatum*		G3	S3	Y
86.100.16	*Sequoia sempervirens – Notholithocarpus densiflorus / Vaccinium ovatum*		G3	S3	Y
86.100.18	*Sequoia sempervirens – Chrysolepis chrysophylla / Arctostaphylos glandulosa*		G2	S2?	Y
86.100.20	*Sequoia sempervirens – Pseudotsuga menziesii – Umbellularia californica*				Y
86.100.21	*Sequoia sempervirens – Umbellularia californica*		G3	S3	Y

Primary Life form: Tree

CaCode	Name		Rarity		Sensitive
86.100.23	*Sequoia sempervirens – Pseudotsuga menziesii – Notholithocarpus densiflorus – Chamaecyparis lawsoniana / Vaccinium ovatum*				Y
86.100.24	*Sequoia sempervirens / Pteridium aquilinum*				Y
86.100.25	*Sequoia sempervirens / Polystichum munitum*				Y
86.100.26	*Sequoia sempervirens – Pseudotsuga menziesii / Rhododendron macrophyllum*				Y
86.100.27	*Sequoia sempervirens – Tsuga heterophylla / Vaccinium ovatum*				Y
86.100.28	*Sequoia sempervirens – Tsuga heterophylla / Polystichum munitum*				Y
86.100.29	*Sequoia sempervirens – Alnus rubra / Rubus spectabilis*				Y
86.100.30	*Sequoia sempervirens – Tsuga heterophylla / Rubus spectabilis*				Y
86.100.31	*Sequoia sempervirens – Pseudotsuga menziesii – Notholithocarpus densiflorus*				Y
86.100.32	*Sequoia sempervirens – Hesperocyparis pigmaea*	Provisional	G1	S1	Y
86.100.33	*Sequoia sempervirens – Pinus muricata*	Provisional			Y
Sequoiadendron giganteum					**Alliance**
86.200.00	**Giant sequoia forest**		**G3**	**S3**	
86.200.01	*Sequoiadendron giganteum – Pinus lambertiana / Cornus nuttallii*				Y
Tsuga heterophylla					**Alliance**
84.200.00	**Western hemlock forest**		**G5**	**S2**	
84.200.01	*Tsuga heterophylla – Pseudotsuga menziesii – Chamaecyparis lawsoniana*				Y
Tsuga mertensiana					**Alliance**
84.100.00	**Mountain hemlock forest**		**G5**	**S4**	
84.100.04	*Tsuga mertensiana*		G3G4		Y
84.100.11	*Tsuga mertensiana – Pinus contorta ssp. murrayana – Pinus monticola*		G3?		Y
84.100.15	*Tsuga mertensiana – Pinus contorta ssp. murrayana*		G3G4		Y
Umbellularia californica					**Alliance**
74.100.00	**California bay forest**		**G4**	**S3**	
74.100.01	*Umbellularia californica*		G3	S3	Y
74.100.03	*Umbellularia californica – Arbutus menziesii*				Y
74.100.05	*Umbellularia californica – Quercus agrifolia / Toxicodendron diversilobum (Corylus cornuta)*				Y
74.100.06	*Umbellularia californica – Aesculus californica / Holodiscus discolor*		G3	S3	Y
74.100.07	*Umbellularia californica / Ceanothus oliganthus*		G3	S3	Y
74.100.08	*Umbellularia californica / Polystichum munitum*				Y
74.100.09	*Umbellularia californica / Toxicodendron diversilobum*				Y
74.100.10	*Umbellularia californica – Acer macrophyllum*		G3	S3?	Y
74.100.11	*Umbellularia californica – Juglans californica / Ceanothus spinosus*		G3	S3	Y
74.100.12	*Umbellularia californica – Notholithocarpus densiflorus*		G3	S3	Y
74.100.13	*Umbellularia californica – Platanus racemosa*		G3	S3	Y
74.100.15	*Umbellularia californica – Quercus agrifolia / (Genista monspessulana)*				Y
74.100.16	*Umbellularia californica – Alnus rhombifolia*		G3	S3	Y
74.100.17	*Umbellularia californica – Pseudotsuga menziesii / Rhododendron occidentale*		G3	S3?	Y
74.100.18	*Umbellularia californica – Quercus wislizeni*				Y

Primary Life form: Tree

CaCode	Name	Rarity		Sensitive
74.100.19	*Umbellularia californica – Quercus agrifolia / Heteromeles arbutifolia – Toxicodendron diversilobum / Melica torreyana*			Y
74.100.20	*Umbellularia californica – Quercus chrysolepis*	G3	S3?	Y
74.100.21	*Umbellularia californica – Quercus agrifolia*			Y
Washingtonia filifera				**Alliance**
61.520.00	**California fan palm oasis**	**G3**	**S3**	
61.520.03	*Washingtonia filifera / spring (Atriplex – Baccharis – Pluchea)*			Y
61.520.04	*Washingtonia filifera – Platanus racemosa / Salix spp*			Y
Yucca brevifolia				**Alliance**
33.170.00	**Joshua tree woodland**	**G4**	**S3**	
33.170.02	*Yucca brevifolia / Coleogyne ramosissima*	G4	S3	Y
33.170.04	*Yucca brevifolia / (Artemisia tridentata – Atriplex confertifolia)*			Y
33.170.06	*Yucca brevifolia / Cylindropuntia acanthocarpa*			Y
33.170.08	*Yucca brevifolia / Lycium andersonii – Ephedra nevadensis*			Y
33.170.10	*Yucca brevifolia / Larrea tridentata – Yucca schidigera / Pleuraphis rigida*	G4		Y
33.170.13	*Yucca brevifolia / (Prunus fasciculata – Salazaria mexicana)*	G3	S3	Y
33.170.16	*Yucca brevifolia / Pleuraphis rigida*	G4	S3	Y
33.170.18	*Yucca brevifolia / (Yucca baccata) / Pleuraphis jamesii – Bouteloua eriopoda*			Y
33.170.19	*Yucca brevifolia / Juniperus californica / Ephedra nevadensis*	G3	S3	Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Acer glabrum		**Provisional**			**Alliance**
61.430.00	**Rocky Mountain maple thickets**		**G5**	**S3?**	
61.430.01	*Acer glabrum drainage bottom*	Provisional			Y
61.430.02	*Acer glabrum Avalanche Chute*	Provisional			Y
Adenostoma fasciculatum					**Alliance**
37.101.00	**Chamise chaparral**		**G5**	**S5**	
37.101.06	*Adenostoma fasciculatum – (Ceanothus greggii / mafic)*				Y
37.101.15	*Adenostoma fasciculatum serpentine*				Y
37.101.19	*Adenostoma fasciculatum – (Arctostaphylos manzanita)*				Y
37.101.20	*Adenostoma fasciculatum – (Ceanothus megacarpus)*		G3	S3	Y
37.101.23	*Adenostoma fasciculatum – Salvia leucophylla*		G3	S3	Y
37.101.28	*Adenostoma fasciculatum – Heteromeles arbutifolia / Melica torreyana*				Y
37.101.32	*Adenostoma fasciculatum – Arctostaphylos glandulosa – Ceanothus jepsonii / Calamagrostis ophitidis*		G2	S2?	Y
37.101.33	*Adenostoma fasciculatum – Malosma laurina – Eriodictyon crassifolium*		G3	S3	Y
37.101.35	*Adenostoma fasciculatum – Arctostaphylos stanfordiana / Salvia sonomensis*				Y
37.101.36	*Adenostoma fasciculatum var. prostratum – (Quercus pacifica)*				Y
37.101.37	*Adenostoma fasciculatum var. prostratum – Salvia brandegeei / Selaginella bigelovii*	Provisional			Y
37.101.38	*Adenostoma fasciculatum Southern Maritime*		G2	S2.2	Y
Adenostoma fasciculatum – Salvia apiana					**Alliance**
37.103.00	**Chamise – white sage chaparral**		**G3**	**S3**	
37.103.01	*Adenostoma fasciculatum – Salvia apiana*				Y
37.103.02	*Adenostoma fasciculatum – Salvia apiana – Artemisia californica*				Y
37.103.03	*Adenostoma fasciculatum – Eriogonum fasciculatum – Salvia apiana*				Y
Adenostoma fasciculatum – Salvia mellifera					**Alliance**
37.102.00	**Chamise – black sage chaparral**		**G4**	**S4**	
37.102.03	*Adenostoma fasciculatum – (Eriogonum fasciculatum – Salvia mellifera)*				Y
37.102.07	*Adenostoma fasciculatum – Salvia mellifera – Rhus ovata*		G3	S3	Y
Adenostoma sparsifolium					**Alliance**
37.501.00	**Redshank chaparral**		**G4**	**S4**	
37.501.01	*Adenostoma sparsifolium*		G3?		Y
37.503.01	*Adenostoma sparsifolium – Adenostoma fasciculatum – Cercocarpus montanus*				Y
37.503.02	*Adenostoma sparsifolium – Adenostoma fasciculatum – Ceanothus greggii*				Y
37.503.03	*Adenostoma sparsifolium – Adenostoma fasciculatum – Arctostaphylos pungens*				Y
37.503.04	*Adenostoma sparsifolium – Adenostoma fasciculatum – Ceanothus crassifolius*		G3	S3	Y
Agave deserti					**Alliance**
33.075.00	**Desert agave scrub**		**G3**	**S3**	
33.075.01	*Agave deserti – Ambrosia salsola (wash and terrace)*				Y
33.075.02	*Agave deserti – Yucca schidigera*				Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Allenrolfea occidentalis					**Alliance**
36.120.00	**Iodine bush scrub**		**G4**	**S3**	
36.120.01	*Allenrolfea occidentalis / Distichlis spicata*	Provisional			Y
36.120.02	*Allenrolfea occidentalis – Suaeda moquinii*				Y
36.120.04	*Allenrolfea occidentalis*		G3		Y
36.120.06	*Allenrolfea occidentalis / Lasthenia gracilis*	Provisional			Y
Alnus incana					**Alliance**
63.210.00	**Mountain alder thicket**		**G4**	**S3**	
63.210.01	*Alnus incana*				Y
63.210.02	*Alnus incana / Glyceria elata*				Y
63.210.03	*Alnus incana / bench*				Y
Alnus viridis		**Provisional**			**Alliance**
63.220.00	**Sitka alder thickets**		**G5**	**S3?**	
Ambrosia dumosa					**Alliance**
33.060.00	**White bursage scrub**		**G5**	**S5**	
33.060.01	*Ambrosia dumosa – Acamptopappus sphaerocephalus*				Y
33.060.02	*Ambrosia dumosa*				Y
Ambrosia salsola – Bebbia juncea					**Alliance**
33.200.00	**Cheesebush – sweetbush scrub**		**G4**	**S4**	
33.200.06	*Ambrosia salsola – (Ambrosia eriocentra – Brickellia incana)*				Y
33.200.12	*Ambrosia eriocentra – Brickellia spp.*	Provisional			Y
35.340.04	*Brickellia incana*	Provisional			Y
Amelanchier utahensis – Cercocarpus montanus – Cercocarpus intric					**Alliance**
76.300.00	**Utah serviceberry – birch leaf mountain mahogany – small leaf mountai**		**G4**	**S2**	
76.300.01	*Cercocarpus intricatus*				Y
76.300.02	*Cercocarpus intricatus – Glossopetalon spinescens*				Y
76.300.03	*Philadelphus microphyllus*	Provisional			Y
76.300.04	*Amelanchier utahensis*				Y
76.300.05	*Cercocarpus montanus / Pseudoroegneria spicata*				Y
Amphipappus fremontii – Salvia funerea					**Alliance**
33.305.00	**Fremont's chaffbush – woolly sage scrub**		**G3**	**S3**	
33.305.01	*Amphipappus fremontii (limestone)*				Y
33.305.02	*Salvia funerea*	Provisional			Y
Arctostaphylos (canescens, manzanita, stanfordiana)					**Alliance**
37.323.00	**Hoary, common, and Stanford manzanita chaparral**		**G3**	**S3**	
37.311.01	*Arctostaphylos canescens – Arctostaphylos glandulosa – Adenostoma fasciculatum*	Provisional			Y
37.323.01	*Arctostaphylos manzanita*		G3	S3	Y
37.323.02	*Arctostaphylos stanfordiana*	Provisional	G3	S3	Y
37.323.03	*Arctostaphylos canescens*	Provisional	G3	S3	Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Arctostaphylos (crustacea, tomentosa)					**Alliance**
37.308.00	**Brittle leaf – woolly leaf manzanita chaparral**		**G3**	**S3**	
37.308.03	*Arctostaphylos crustacea*		G3	S3	Y
37.308.04	*Arctostaphylos crustacea – Adenostoma fasciculatum – Ceanothus (cuneatus, papillosus)*				Y
37.308.05	*Arctostaphylos crustacea – Arctostaphylos gabilanensis*				Y
37.308.06	*Arctostaphylos confertiflora*		G2	S2	Y
37.308.07	*Arctostaphylos insularis*				Y
37.308.08	*Arctostaphylos catalinae*	Provisional			Y
Arctostaphylos (nummularia, sensitiva)					**Alliance**
37.306.00	**Glossy leaf manzanita chaparral**		**G2G3**	**S2S3**	
37.306.01	*Arctostaphylos sensitiva – Vaccinium ovatum – Chrysolepis chrysophylla var. minor*		G2	S2	Y
37.306.02	*Arctostaphylos sensitiva – Arctostaphylos glandulosa*				Y
37.306.03	*Arctostaphylos nummularia*		G2	S2	Y
Arctostaphylos (purissima, rudis)					**Special Stands**
37.322.00	**Burton Mesa chaparral**		**G1**	**S1**	
Arctostaphylos bakeri					**Special Stands**
37.317.00	**Stands of Baker manzanita**		**G1**	**S1**	
Arctostaphylos glandulosa					**Alliance**
37.302.00	**Eastwood manzanita chaparral**		**G4**	**S4**	
37.106.05	*Arctostaphylos glandulosa – Adenostoma fasciculatum / mafic soils*				Y
37.106.10	*Arctostaphylos glandulosa – Adenostoma fasciculatum – Quercus wislizeni*		G3	S3?	Y
37.106.14	*Arctostaphylos glandulosa – Adenostoma fasciculatum – Chamaebatia australis*				Y
37.302.01	*Arctostaphylos glandulosa*		G3G4		Y
37.302.02	*Arctostaphylos glandulosa ssp. adamsii*				Y
37.302.04	*Arctostaphylos glandulosa – Quercus wislizeni*		G3	S3?	Y
37.302.07	*Arctostaphylos glandulosa – Arctostaphylos pringlei*				Y
Arctostaphylos glauca					**Alliance**
37.301.00	**Bigberry manzanita chaparral**		**G4**	**S4**	
37.104.11	*Arctostaphylos glauca – Adenostoma fasciculatum on serpentine*		G3	S3	Y
37.301.01	*Arctostaphylos glauca*		G3G4		Y
37.301.02	*Arctostaphylos glauca / Melica torreyana*				Y
37.301.04	*Arctostaphylos glauca – Quercus durata / Pinus sabiniana*		G3	S3	Y
37.301.06	*Arctostaphylos glauca – Quercus john-tuckeri*	Provisional			Y
Arctostaphylos hookeri		**Provisional**			**Alliance**
37.321.00	**Hooker's manzanita chaparral**		**G2**	**S2**	
Arctostaphylos hooveri					**Alliance**
37.312.00	**Hoover's manzanita chaparral**		**G2**	**S2**	

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CaCode	Name		Rarity		Sensitive
37.312.01	*Arctostaphylos hooveri*				Y
Arctostaphylos montana					**Alliance**
37.307.00	**Mount Tamalpais manzanita chaparral**		**G2**	**S2**	
37.307.01	*Arctostaphylos montana*		G1	S2	Y
37.307.02	*Arctostaphylos montana – Adenostoma fasciculatum*		G2	S2	Y
Arctostaphylos montereyensis		**Provisional**			**Alliance**
37.314.00	**Monterey manzanita chaparral**		**G1**	**S1**	
Arctostaphylos morroensis					**Alliance**
37.315.00	**Morro manzanita chaparral**		**G1**	**S1**	
37.315.01	*Arctostaphylos morroensis*	Provisional			Y
Arctostaphylos myrtifolia					**Alliance**
37.304.00	**Ione manzanita chaparral**		**G1**	**S1**	
37.304.01	*Arctostaphylos myrtifolia*				Y
Arctostaphylos pajaroensis					**Alliance**
37.316.00	**Pajaro manzanita chaparral**		**G1**	**S1**	
37.316.01	*Arctostaphylos pajaroensis*				Y
Arctostaphylos patula – Arctostaphylos nevadensis					**Alliance**
37.303.00	**Green leaf manzanita – Pinemat manzanita chaparral**		**G5**	**S3S4**	
37.303.01	*Arctostaphylos patula*		G5?		N
37.303.02	*Arctostaphylos patula – Quercus vacciniifolia*				N
37.303.03	*Arctostaphylos nevadensis*	Provisional			N
Arctostaphylos pumila		**Provisional**			**Alliance**
37.318.00	**Sandmat manzanita chaparral**		**G1**	**S1**	
Arctostaphylos pungens – Arctostaphylos pringlei					**Alliance**
37.310.00	**Pointleaf manzanita – pink-bract manzanita chaparral**		**G4**	**S3**	
37.310.01	*Arctostaphylos pringlei ssp. drupacea – Arctostaphylos pungens*				Y
37.310.02	*Arctostaphylos pringlei ssp. drupacea*				Y
37.310.03	*Adenostoma fasciculatum – Arctostaphylos pringlei*				Y
37.310.04	*Arctostaphylos parryana*	Provisional			Y
Arctostaphylos silvicola		**Provisional**			**Alliance**
37.320.00	**Silverleaf manzanita chaparral**		**G1**	**S1**	
Arctostaphylos viscida					**Alliance**
37.305.00	**Whiteleaf manzanita chaparral**		**G4**	**S4**	
37.305.03	*Arctostaphylos viscida / Salvia sonomensis*	Provisional			Y
37.305.04	*(Arctostaphylos viscida – Adenostoma fasciculatum) / Salvia sonomensis*				Y
37.305.08	*Arctostaphylos viscida – Ceanothus jepsonii*	Provisional			Y
Artemisia arbuscula ssp. arbuscula					**Alliance**
35.120.00	**Little sagebrush scrub**		**G5**	**S4**	
35.120.01	*Artemisia arbuscula / Trifolium andersonii ssp. monoense*				Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
35.120.03	*Artemisia arbuscula / Festuca idahoensis*				Y
35.120.05	*Artemisia arbuscula – Eriogonum (microthecum, sphaerocephalum)*		G2G3 ?		Y
35.120.14	*Artemisia arbuscula / Poa secunda*				Y
Artemisia californica					**Alliance**
32.010.00	**California sagebrush scrub**		**G5**	**S5**	
32.010.09	*Artemisia californica – Lepidospartum squamatum*		G3	S3	Y
32.010.11	*Artemisia californica – Diplacus aurantiacus*		G3	S3	Y
32.010.14	*Artemisia californica – (Salvia leucophylla) / Leymus condensatus*		G3	S3	Y
32.010.16	*Artemisia californica – Opuntia littoralis*	Provisional			Y
32.010.18	*Artemisia californica – Cleome isomeris*	Provisional			Y
32.010.19	*Artemisia californica – Salvia brandegeei*				Y
32.010.20	*Artemisia californica / Nassella (pulchra)*				Y
Artemisia californica – Eriogonum fasciculatum					**Alliance**
32.110.00	**California sagebrush – California buckwheat scrub**		**G4**	**S4**	
32.110.03	*Artemisia californica – Eriogonum fasciculatum – Salvia leucophylla*		G3	S3	Y
32.110.04	*Artemisia californica – Eriogonum fasciculatum – Salvia mellifera*		G3	S3?	Y
32.110.07	*Artemisia californica – Eriogonum fasciculatum – Ephedra californica*		G3	S3	Y
32.110.08	*Artemisia californica – Eriogonum fasciculatum – Opuntia littoralis / Dudleya (edulis)*		G3	S2	Y
32.110.09	*Artemisia californica – Eriogonum fasciculatum – Viguiera laciniata*				Y
Artemisia cana					**Alliance**
35.150.00	**Silver sagebrush scrub**		**G5**	**S3**	
35.150.04	*Artemisia cana / Juncus arcticus var. balticus*				Y
35.150.05	*Artemisia cana / Iris missouriensis – Juncus arcticus var. balticus*				Y
35.150.07	*Artemisia cana / mesic (Poa secunda – Poa cusickii)*				Y
35.150.08	*Artemisia cana (ssp. bolanderi, ssp. viscidula) / Poa secunda*				Y
Artemisia nova					**Alliance**
35.130.00	**Black sagebrush scrub**		**G4**	**S3**	
35.130.01	*Artemisia nova*		G3G5		Y
35.130.03	*Artemisia nova – Ambrosia salsola*				Y
Artemisia rothrockii					**Alliance**
35.140.00	**Rothrock's sagebrush**		**G3**	**S3**	
35.140.01	*Artemisia rothrockii / Penstemon heterodoxus*				Y
35.140.02	*Artemisia rothrockii / Monardella odoratissima*		G3?		Y
Artemisia tridentata					**Alliance**
35.110.00	**Big sagebrush**		**G5**	**S5**	
35.110.16	*Artemisia tridentata ssp. parishii*	Provisional	G2	S2	Y
35.110.17	*Artemisia tridentata / Pleuraphis jamesii*				Y
Artemisia tridentata ssp. vaseyana					**Alliance**
35.111.00	**Mountain big sagebrush**		**G4**	**S4**	
35.111.05	*Artemisia tridentata – Salvia dorrii – Chamaebatiaria millefolium*				Y
35.111.07	*Artemisia tridentata ssp. vaseyana / Festuca idahoensis*				Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Atriplex canescens					**Alliance**
36.310.00	**Fourwing saltbush scrub**		**G5**	**S4**	
36.310.03	*Atriplex canescens / herbaceous*	Provisional			Y
Atriplex confertifolia					**Alliance**
36.320.00	**Shadscale scrub**		**G5**	**S4**	
36.320.07	*Atriplex confertifolia – Lycium andersonii*		G3		Y
36.320.08	*Atriplex confertifolia – Krascheninnikovia lanata*		G3G5		Y
36.320.13	*Atriplex confertifolia – Lepidium fremontii*				Y
36.320.14	*Atriplex confertifolia – Picrothamnus desertorum*				Y
Atriplex hymenelytra					**Alliance**
36.330.00	**Desert holly scrub**		**G5**	**S4**	
36.330.03	*Atriplex hymenelytra – Larrea tridentata*		G4	S3	Y
36.330.07	*Hoffmannseggia microphylla*	Provisional			Y
Atriplex lentiformis					**Alliance**
36.370.00	**Quailbush scrub**		**G4**	**S4**	
36.370.04	*Atriplex torreyi*				Y
36.370.05	*Atriplex torreyi / Distichlis spicata – Sporobolus airoides*	Provisional			Y
Atriplex spinifera					**Alliance**
36.350.00	**Spinescale scrub**		**G4**	**S4**	
36.350.01	*Atriplex spinifera*				Y
36.350.02	*Atriplex spinifera / herbaceous*		G3	S3	Y
36.350.03	*Atriplex spinifera – Picrothamnus desertorum*				Y
Baccharis emoryi – Baccharis sergiloides					**Alliance**
63.550.00	**Emory's and Broom baccharis scrub**		**G4**	**S3**	
63.520.01	*Baccharis emoryi*	Provisional			Y
63.530.02	*Baccharis sergiloides – Prunus fasciculata – Rhus trilobata*				Y
63.530.03	*Baccharis sergiloides / (Muhlenbergia rigens – Typha domingensis)*				Y
63.550.01	*Baccharis sergiloides*				Y
Baccharis pilularis					**Alliance**
32.060.00	**Coyote brush scrub**		**G5**	**S5**	
32.060.01	*Baccharis pilularis / Eriophyllum staechadifolium*		G3	S3	Y
32.060.02	*Baccharis pilularis / Deschampsia cespitosa*		G2	S1	Y
32.060.03	*Baccharis pilularis / Leymus triticoides*				Y
32.060.04	*Baccharis pilularis / Polystichum munitum*		G3	S3?	Y
32.060.11	*Baccharis pilularis / Danthonia californica*		G2	S2	Y
32.060.12	*Baccharis pilularis – Holodiscus discolor*		G3	S3?	Y
32.060.13	*Baccharis pilularis / Carex obnupta – Juncus patens*	Provisional	G3	S3?	Y
32.060.14	*Baccharis pilularis – Ceanothus thyrsiflorus*		G3	S3?	Y
32.060.21	*Baccharis pilularis / (Nassella pulchra – Elymus glaucus – Bromus carinatus)*		G3	S3	Y
32.060.24	*Baccharis pilularis / Dudleya farinosa*		G3	S3?	Y
32.060.30	*Baccharis pilularis – Frangula californica – Rubus spp.*	Provisional	G2	S2?	Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Baccharis salicifolia					**Alliance**
63.510.00	**Mulefat thickets**		**G4**	**S4**	
63.510.02	*Baccharis salicifolia – Lepidospartum squamatum – Hazardia squarrosa*		G3	S3	Y
Betula glandulosa		**Provisional**			**Alliance**
63.620.00	**Resin birch thickets**		**G5**	**S2?**	
Betula occidentalis					**Alliance**
63.610.00	**Water birch thicket**		**G4**	**S2**	
63.610.01	*Betula occidentalis / Salix spp.*				Y
63.610.02	*Betula occidentalis / Mesic graminoids*				Y
Carnegiea gigantea – Parkinsonia microphylla – Prosopis velutina		**Provisional**			**Alliance**
33.150.00	**Saguaro – foothill palo verde – velvet mesquite desert scrub**		**G4**	**S2**	
33.150.01	*Parkinsonia microphylla – Larrea tridentata*	Provisional	G4	S2	Y
Cassiope mertensiana		**Provisional**			**Alliance**
91.126.00	**White mountain heather heath**		**G5**	**S3?**	
Castela emoryi					**Special Stands**
33.110.00	**Crucifixion thorn stands**		**G2**	**S1**	
Ceanothus (oliganthus, tomentosus)					**Alliance**
37.207.00	**Hairy leaf - woolly leaf ceanothus chaparral**		**G3**	**S3**	
37.207.01	*Ceanothus oliganthus*		G4		Y
37.207.02	*Ceanothus oliganthus – Adenostoma fasciculatum*				Y
37.207.03	*Ceanothus oliganthus – Adenostoma fasciculatum – Xylococcus bicolor*				Y
37.207.04	*Ceanothus oliganthus – Adenostoma sparsifolium*		G2	S2	Y
37.207.05	*Ceanothus oliganthus – Arctostaphylos glandulosa*				Y
37.207.06	*Ceanothus oliganthus – Eriodictyon crassifolium*				Y
37.207.07	*Ceanothus oliganthus – Heteromeles arbutifolia – Rhus ovata*		G4		Y
37.207.08	*Ceanothus oliganthus – Quercus berberidifolia*		G3	S3	Y
37.207.09	*Ceanothus tomentosus*		G3	S3	Y
37.207.10	*Ceanothus cyaneus*	Provisional			Y
Ceanothus cordulatus					**Alliance**
37.209.00	**Mountain whitethorn chaparral**		**G4**	**S4**	
37.209.01	*Ceanothus cordulatus*		G3?		Y
Ceanothus cuneatus					**Alliance**
37.211.00	**Wedge leaf ceanothus chaparral, Buck brush chaparral**		**G4**	**S4**	
37.211.05	*Ceanothus cuneatus / Plantago erecta*				Y
37.211.10	*Ceanothus cuneatus – Adenostoma fasciculatum – Salvia mellifera – Malosma laurina*		G3	S3	Y
Ceanothus greggii – Fremontodendron californicum					**Alliance**
37.212.00	**Cup leaf ceanothus – California flannelbush chaparral**		**G4**	**S3**	
37.212.01	*Ceanothus greggii (var. vestitus, var. perplexans)*				Y
37.212.03	*Ceanothus greggii – Adenostoma fasciculatum*				Y

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CaCode	Name		Rarity		Sensitive
37.212.05	*Fremontodendron californicum*				Y
Ceanothus integerrimus					**Alliance**
37.206.00	**Deer brush chaparral**		**G4**	**S4**	
37.206.05	*Ceanothus integerrimus – Quercus garryana var. fruticosa*				Y
Ceanothus megacarpus					**Alliance**
37.201.00	**Bigpod ceanothus chaparral**		**G4**	**S4**	
37.201.04	*Ceanothus megacarpus – Adenostoma sparsifolium*		G3	S3	Y
37.201.05	*Ceanothus megacarpus – Cercocarpus montanus*		G3	S3	Y
37.201.08	*Ceanothus megacarpus – Salvia mellifera*		G3	S3	Y
37.201.10	*Ceanothus megacarpus var. insularis*	Provisional			Y
Ceanothus papillosus					**Alliance**
37.215.00	**Wart leaf ceanothus chaparral**		**G3**	**S3**	
37.215.01	*Ceanothus papillosus – Adenostoma fasciculatum*				Y
Ceanothus thyrsiflorus					**Alliance**
37.204.00	**Blue blossom chaparral**		**G4**	**S4**	
37.204.02	*Ceanothus thyrsiflorus – Rubus ursinus*		G3	S3?	Y
37.204.03	*Ceanothus thyrsiflorus – Vaccinium ovatum – Rubus parviflorus*		G3	S3?	Y
37.204.04	*Ceanothus incanus*	Provisional			Y
37.204.05	*Ceanothus arboreus*				Y
Ceanothus velutinus					**Alliance**
37.210.00	**Tobacco brush or snow bush chaparral**		**G5**	**S4**	
37.210.02	*Ceanothus velutinus – Prunus emarginata – Artemisia tridentata*		G3?		Y
Ceanothus verrucosus		**Provisional**			**Alliance**
37.216.00	**Wart-stemmed ceanothus chaparral**		**G2**	**S2**	
37.216.01	*Ceanothus verrucosus – Xylococcus bicolor*	Provisional			Y
Celtis laevigata var. reticulata – Rhus trilobata		**Provisional**			**Alliance**
61.565.00	**Sugarberry – skunkbush sumac scrub**		**G3**	**S1**	
61.565.01	*Celtis laevigata var. reticulata*	Provisional			Y
Cephalanthus occidentalis					**Alliance**
63.300.00	**Button willow thickets**		**G5**	**S2**	
63.300.01	*Cephalanthus occidentalis*				Y
Cercocarpus ledifolius					**Alliance**
76.200.00	**Curl leaf mountain mahogany scrub**		**G5**	**S4**	
76.200.02	*Cercocarpus ledifolius / Symphoricarpos rotundifolius*		G3G4		Y
Cercocarpus montanus					**Alliance**
76.100.00	**Birch leaf mountain mahogany chaparral**		**G5**	**S4**	
76.100.05	*Cercocarpus montanus – Ceanothus spinosus*		G3	S3	Y
76.100.09	*Cercocarpus montanus – Ceanothus cuneatus – Quercus john-tuckeri*		G3	S3	Y
76.100.12	*Cercocarpus montanus – Malosma laurina – Artemisia californica*		G3	S3	Y
76.100.18	*Cercocarpus montanus var. blancheae*	Provisional			Y
Chrysolepis chrysophylla					**Alliance**
37.417.00	**Golden chinquapin thickets**		**G2**	**S2**	

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
37.417.01	*Chrysolepis chrysophylla / Vaccinium ovatum*				Y
37.417.02	*Chrysolepis chrysophylla – Arctostaphylos glandulosa*				Y
Chrysolepis sempervirens					**Alliance**
37.700.00	**Bush chinquapin chaparral**		**G4**	**S3**	
37.700.01	*Chrysolepis sempervirens*		G3	S3	Y
Coleogyne ramosissima					**Alliance**
33.020.00	**Black brush scrub**		**G5**	**S4**	
33.020.01	*Coleogyne ramosissima*		G4G5		Y
33.020.14	*Coleogyne ramosissima / Pleuraphis jamesii*				Y
Coreopsis gigantea					**Alliance**
43.100.00	**Giant coreopsis scrub**		**G3**	**S3**	
43.100.01	*Coreopsis gigantea – Artemisia californica – Eriogonum cinereum*		G3	S3	Y
43.100.02	*Coreopsis gigantea – Ericameria ericoides – Encelia californica*		G2	S2	Y
43.100.03	*Coreopsis gigantea – Lotus dendroideus*	Provisional			Y
43.100.04	*Coreopsis gigantea / (Dudleya greenei)*				Y
43.100.05	*Coreopsis gigantea – (Lycium californicum – Opuntia spp.)*				Y
Cornus sericea					**Alliance**
80.100.00	**Red osier thickets**		**G4**	**S3?**	
80.100.03	*Cornus sericea – Salix exigua*				Y
80.100.04	*Cornus sericea – Salix lasiolepis*				Y
Cornus sericea – Rosa woodsii – Ribes spp.					**Alliance**
63.320.00	**Red-osier dogwood - Interior rose - Currant thickets**		**G5**	**S3**	
63.320.01	*Rosa woodsii*				N
80.100.01	*Cornus sericea / Senecio triangularis*				Y
80.100.02	*Cornus sericea*				Y
Corylus cornuta var. californica					**Alliance**
37.950.00	**Hazelnut scrub**		**G3**	**S2?**	
37.950.01	*Corylus cornuta / Polystichum munitum*		G2	S2?	Y
Cylindropuntia acanthocarpa / Pleuraphis rigida					**Alliance**
33.055.00	**Buckhorn cholla / big galleta grass scrub**		**GNR**	**S4**	
33.055.01	*Cylindropuntia acanthocarpa var. coloradensis*				Y
Cylindropuntia bigelovii					**Alliance**
33.050.00	**Teddy bear cholla patches**		**G4**	**S3**	
33.050.01	*Cylindropuntia bigelovii*		G4	S3	Y
Dasiphora fruticosa					**Alliance**
38.110.00	**Shrubby cinquefoil scrub**		**G5**	**S3?**	
38.110.01	*Dasiphora fruticosa*				Y
38.110.02	*Dasiphora fruticosa / Danthonia intermedia*				Y
38.110.03	*Dasiphora fruticosa / Potentilla breweri*				Y
38.110.04	*Dasiphora fruticosa / Danthonia unispicata*				Y
38.110.05	*Dasiphora fruticosa / Veratrum californicum*				Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Deinandra clementina – Eriogonum giganteum					**Alliance**
43.110.00	**Island tar plant – Saint Catherine's lace scrub**		**G2**	**S2**	
43.110.01	*Deinandra clementina*				Y
43.110.02	*Constancea nevinii*	Provisional			Y
43.110.03	*Eriogonum giganteum var. compactum*	Provisional			Y
43.110.04	*Eriogonum giganteum var. giganteum*	Provisional			Y
Diplacus aurantiacus					**Alliance**
32.082.00	**Bush monkeyflower scrub**		**G3**	**S3?**	
32.082.01	*Diplacus aurantiacus*		G3	S3	Y
32.082.02	*Diplacus parviflorus*	Provisional			Y
Encelia (actonii, virginensis) – Viguiera reticulata					**Alliance**
33.037.00	**Acton's and Virgin River brittle brush – net-veined goldeneye scrub**		**G3**	**S3**	
33.025.01	*Encelia virginensis*				Y
33.025.03	*Encelia actonii*		G3	S3	Y
33.033.01	*Viguiera reticulata*		G1	S1	Y
Encelia californica – Eriogonum cinereum					**Alliance**
32.051.00	**California brittle bush – Ashy buckwheat scrub**		**G3**	**S3**	
32.035.01	*Eriogonum cinereum*		G2G3	S2S3	Y
32.050.01	*Encelia californica – Artemisia californica*		G3		Y
32.050.02	*Encelia californica*		G3		Y
32.050.03	*Encelia californica – Artemisia californica – Salvia mellifera – Baccharis pilularis*				Y
32.050.04	*Encelia californica – Eriogonum cinereum*		G3	S3	Y
32.050.05	*Encelia californica – Malosma laurina – Salvia mellifera*		G3	S3?	Y
32.050.06	*Encelia californica – Rhus integrifolia*		G3	S3	Y
32.051.01	*Encelia californica – Eriogonum arborescens*	Provisional			Y
Encelia farinosa					**Alliance**
33.030.00	**Brittle bush scrub**		**G5**	**S4**	
33.030.02	*Encelia farinosa – Peucephyllum schottii*				Y
33.030.03	*Encelia farinosa – Eriogonum fasciculatum – Agave deserti*				Y
Ephedra californica – Ephedra trifurca					**Alliance**
33.270.00	**California joint fir – longleaf joint-fir scrub**		**G5**	**S4**	
33.270.01	*Ephedra californica*		G3	S3	Y
33.270.02	*Ephedra californica – Ambrosia salsola*				Y
33.270.03	*Ephedra californica / annual – perennial herb*		G3	S3	Y
33.270.04	*Ephedra californica – Gutierrezia californica / Eriastrum pluriflorum*		G2	S2	Y
33.270.05	*Ephedra trifurca*			S3	Y
Ephedra funerea					**Alliance**
33.275.00	**Death Valley joint fir scrub**		**G3**	**S3**	
33.275.01	*Ephedra funerea*				Y
Ephedra nevadensis – Lycium andersonii – Grayia spinosa					**Alliance**
33.185.00	**Nevada joint fir – Anderson's boxthorn – spiny hop sage scrub**		**G5**	**S3S4**	

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
33.180.01	*Grayia spinosa*		GNR		N
33.180.03	*Grayia spinosa – Larrea tridentata*				Y
33.180.04	*Grayia spinosa – Lycium andersonii*		G5		Y
33.180.05	*Grayia spinosa / Eriogonum ovalifolium*				Y
33.180.06	*Grayia spinosa – Ephedra viridis*				Y
33.180.07	*Grayia spinosa – Picrothamnus desertorum*				Y
33.185.01	*Lycium cooperi*	Provisional			N
33.185.02	*Ephedra nevadensis / (Elymus elymoides)*	Provisional			N
33.185.03	*Grayia spinosa – Lycium pallidum*				Y
33.185.04	*Grayia spinosa – Tetradymia (axillaris, glabrata)*	Provisional			N
33.280.01	*Ephedra nevadensis – (Salazaria mexicana – Ambrosia salsola)*				N
33.280.04	*Ephedra nevadensis – Lycium andersonii*				N
33.280.05	*Ephedra nevadensis – Ericameria cooperi*		G3G4	S3S4	Y
33.360.01	*Lycium andersonii – Simmondsia chinensis – Pleuraphis rigida*		G4	S3	Y
33.360.02	*Lycium andersonii*	Provisional			Y
Ericameria linearifolia – Cleome isomeris					**Alliance**
38.125.00	**Narrowleaf goldenbush – bladderpod scrub**		**G4**	**S4**	
38.125.01	*Ericameria linearifolia*				Y
38.125.02	*Eastwoodia elegans*		G3	S3	Y
38.125.03	*Cleome isomeris*				Y
38.125.04	*Eastwoodia elegans – Krascheninnikovia lanata*				Y
Ericameria nauseosa					**Alliance**
35.310.00	**Rubber rabbitbrush scrub**		**G5**	**S5**	
35.310.04	*Lepidospartum latisquamum*				Y
Ericameria palmeri		**Provisional**			**Alliance**
38.130.00	**Palmer's goldenbush scrub**		**G3**	**S3?**	
38.130.01	*Ericameria palmeri*	Provisional			Y
Ericameria paniculata					**Alliance**
35.340.00	**Black-stem rabbitbrush scrub**		**G4**	**S3**	
35.340.01	*Ericameria paniculata*				Y
35.340.02	*Ericameria paniculata – Ambrosia salsola*				Y
35.340.03	*Ericameria paniculata – Ambrosia eriocentra*				Y
Ericameria parryi					**Alliance**
35.320.00	**Parry's rabbitbrush scrub**		**G4**	**S3**	
35.320.01	*Ericameria parryi / Gayophytum diffusum*				Y
Eriodictyon crassifolium		**Provisional**			**Alliance**
37.090.00	**Thick leaf yerba santa scrub**		**G3**	**S3**	
Eriogonum arborescens – Eriogonum grande					**Alliance**
32.036.00	**Island Buckwheat scrub**		**G3**	**S3**	
32.010.17	*Artemisia californica – Eriogonum arborescens*				Y
32.036.01	*Eriogonum arborescens – Hazardia detonsa*				Y
32.036.02	*Eriogonum arborescens*				Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
32.036.03	*Eriogonum grande var. grande*				Y
32.036.04	*Eriogonum grande var. rubescens*	Provisional	G1	S1	Y
Eriogonum fasciculatum					**Alliance**
32.040.00	**California buckwheat scrub**		**G5**	**S5**	
32.040.03	*Eriogonum fasciculatum – Artemisia tridentata*				Y
32.040.13	*Eriogonum fasciculatum var. foliolosum – Juniperus californica*		G3	S3	Y
32.040.15	*Eriogonum fasciculatum var. polifolium / Eriastrum pluriflorum*		G2	S2	Y
32.040.20	*Eriogonum fasciculatum – Ephedra californica*	Provisional			Y
32.040.21	*Eriogonum fasciculatum / Salvia columbariae – Mirabilis laevis*	Provisional			Y
32.040.22	*Hesperoyucca whipplei*	Provisional	G3G4	S3S4	Y
Eriogonum fasciculatum – Salvia apiana					**Alliance**
32.100.00	**California buckwheat – white sage scrub**		**G4**	**S4**	
32.100.01	*Eriogonum fasciculatum – Salvia apiana*				Y
32.100.02	*Salvia apiana – Artemisia californica – Ericameria spp.*				Y
Eriogonum fasciculatum – Viguiera parishii					**Alliance**
33.032.00	**California buckwheat – Parish's goldeneye scrub**		**G4**	**S4**	
33.032.01	*Viguiera parishii – Agave deserti*				Y
33.032.06	*Eriogonum fasciculatum rock outcrop*				Y
33.032.07	*Eriogonum fasciculatum – Ericameria (laricifolia, linearifolia)*				Y
33.032.08	*Viguiera parishii – Eriogonum fasciculatum – Simmondsia chinensis*				Y
Eriogonum wrightii – Eriogonum heermannii – Buddleja utahensis					**Alliance**
32.046.00	**Wright's buckwheat – Heermann's buckwheat – Utah butterfly-bush scr**		**G3**	**S3**	
32.041.01	*Eriogonum wrightii – Eriophyllum confertiflorum / Monardella antonina ssp. benitensis*		G2	S2	Y
32.041.02	*Eriogonum wrightii – Juniperus californica*		G3	S3	Y
32.041.03	*Eriogonum wrightii – Corethrogyne filaginifolia*				Y
32.046.01	*Hecastocleis shockleyi*	Provisional			Y
32.046.02	*(Buddleja utahensis – Eriogonum heermannii) – Gutierrezia spp. limestone*				Y
32.046.03	*Eriogonum heermannii*	Provisional			Y
32.046.04	*Eriogonum wrightii (ssp. subscaposum, ssp. wrightii)*	Provisional			Y
Fallugia paradoxa		**Provisional**			**Alliance**
33.325.00	**Apache plume scrub**		**GNR**	**S3**	
33.325.01	*Fallugia paradoxa Desert Wash*				Y
Frangula californica					**Alliance**
37.920.00	**California coffee berry scrub**		**G4**	**S4**	
37.920.04	*Frangula californica ssp. tomentella / Hoita macrostachya*				Y
Garrya elliptica		**Provisional**			**Alliance**
39.040.00	**Coastal silk tassel scrub**		**G3?**	**S3?**	
Gutierrezia californica		**Provisional**			**Alliance**
32.042.00	**California match weed patches**		**G3?**	**S3?**	
32.042.01	*Gutierrezia californica / Annual – perennial grass – herb*	Provisional			Y
32.042.02	*Gutierrezia californica / Poa secunda*				Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Gutierrezia sarothrae – Gutierrezia microcephala					**Alliance**
32.043.00	**Snakeweed scrub**		**G3**	**S3**	
32.043.01	*Gutierrezia sarothrae / Pleuraphis rigida – Sphaeralcea ambigua*				Y
32.043.02	*Gutierrezia (microcephala, sarothrae)*				Y
32.043.03	*Gutierrezia sarothrae – Erodium spp. – Nassella pulchra*	Provisional			Y
Hazardia squarrosa					**Alliance**
32.055.00	**Sawtooth golden bush scrub**		**G3**	**S3**	
32.055.01	*Hazardia squarrosa / Nassella pulchra – Deinandra fasciculata*		G3	S3	Y
32.055.02	*Hazardia squarrosa – Artemisia californica*		G3	S3	Y
Holodiscus discolor					**Alliance**
39.100.00	**Ocean spray brush**		**G4**	**S3**	
39.100.01	*Holodiscus discolor / Mimulus suksdorfii*				Y
39.100.02	*Holodiscus discolor / Achnatherum occidentale – Eriogonum nudum*				Y
39.100.03	*Holodiscus discolor – Arctostaphylos patula*				Y
39.100.04	*Holodiscus discolor – Keckiella corymbosa*				Y
39.100.05	*Holodiscus discolor / Sedum obtusatum ssp. boreale – Cryptogramma acrostichoides*				Y
39.100.06	*Holodiscus discolor – Sambucus racemosa*				Y
Isocoma menziesii					**Alliance**
32.044.00	**Menzies's golden bush scrub**		**G3**	**S3**	
32.044.03	*Isocoma menziesii – Lupinus albifrons*		G3	S3	Y
32.044.04	*Isocoma menziesii*		G3	S3	Y
32.044.05	*Isocoma menziesii – Lotus dendroideus*		G1	S1	Y
32.044.06	*Isocoma menziesii – Artemisia californica*		G3	S3	Y
32.044.07	*Isocoma menziesii / Dudleya greenei*				Y
32.044.08	*Isocoma menziesii / (Astragalus miguelensis – Atriplex californica)*		G3	S3	Y
Kalmia microphylla		**Provisional**			**Alliance**
45.406.00	**Alpine laurel heath**		**G4**	**S3?**	
Keckiella antirrhinoides					**Alliance**
32.065.00	**Bush penstemon scrub**		**G3**	**S3**	
32.065.01	*Keckiella antirrhinoides*				Y
32.065.02	*Keckiella antirrhinoides – Artemisia californica*				Y
32.065.03	*Keckiella antirrhinoides – Eriogonum fasciculatum*				Y
32.065.04	*Keckiella antirrhinoides – Mixed Chaparral*				Y
Koeberlinia spinosa					**Special Stands**
33.100.00	**Crown-of-thorns stands**		**G2**	**S1**	
Krascheninnikovia lanata					**Alliance**
36.500.00	**Winterfat scrubland**		**G4**	**S3**	
36.500.01	*Krascheninnikovia lanata*				Y
Larrea tridentata					**Alliance**
33.010.00	**Creosote bush scrub**		**G5**	**S5**	

Primary Life form: Shrub

CaCode	Name	Rarity		Sensitive
33.010.07	*Larrea tridentata – Krameria grayi – Pleuraphis rigida*			Y
33.010.13	*Larrea tridentata – Pleuraphis rigida*	G4	S3	Y
33.010.14	*Larrea tridentata – Pleuraphis rigida – Lycium andersonii*			Y
Larrea tridentata – Ambrosia dumosa				**Alliance**
33.140.00	**Creosote bush – white bursage scrub**	**G5**	**S5**	
33.140.07	*Larrea tridentata – Ambrosia dumosa – Psorothamnus schottii*	G4	S3	Y
33.140.08	*Larrea tridentata – Ambrosia dumosa – Psorothamnus emoryi – sandy*			Y
33.140.10	*Larrea tridentata – Ambrosia dumosa – Galium angustifolium – Lyrocarpa coulteri*			Y
33.140.13	*Larrea tridentata – Ambrosia dumosa – Senna armata*	G4	S3	Y
33.140.17	*Larrea tridentata – Ambrosia dumosa / Pleuraphis rigida*	G4	S3	Y
33.140.29	*Larrea tridentata – Ambrosia dumosa – Ephedra funerea*			Y
33.140.31	*Larrea tridentata – Ambrosia dumosa – Encelia virginensis*			Y
33.140.34	*Larrea tridentata – Ambrosia dumosa / Dalea mollissima*			Y
33.140.35	*Larrea tridentata – Ambrosia dumosa / Cryptogamic crust*			Y
33.140.41	*Larrea tridentata – Ambrosia dumosa – Fagonia laevis*			Y
33.140.56	*Larrea tridentata – Ambrosia dumosa – Psorothamnus (arborescens, fremontii)*			Y
Larrea tridentata – Encelia farinosa				**Alliance**
33.027.00	**Creosote bush – brittle bush scrub**	**G5**	**S4**	
33.027.04	*Larrea tridentata – Encelia farinosa – Fouquieria splendens*	G5	S3	Y
Lepidospartum squamatum				**Alliance**
32.070.00	**Scale broom scrub**	**G3**	**S3**	
32.070.01	*Eriogonum fasciculatum – Lepidospartum squamatum alluvial fan*			Y
32.070.02	*Lepidospartum squamatum – Eriodictyon crassifolium – Hesperoyucca whipplei*			Y
32.070.03	*Lepidospartum squamatum / ephemeral annuals*	G2	S2	Y
32.070.04	*Lepidospartum squamatum – Atriplex canescens*			Y
32.070.05	*Lepidospartum squamatum – Baccharis salicifolia*			Y
32.070.06	*Lepidospartum squamatum – Eriogonum fasciculatum*			Y
32.070.07	*Lepidospartum squamatum / Amsinckia menziesii*			Y
32.070.08	*Lepidospartum squamatum – Eriodictyon trichocalyx – Hesperoyucca whipplei*			Y
32.070.09	*Lepidospartum squamatum – Artemisia californica*			Y
32.070.10	*Lepidospartum squamatum / desert ephemeral annuals*			Y
Lupinus arboreus				**Alliance and Semi-Natural Alliance**
32.080.00	**Yellow bush lupine scrub**	**G4**	**S4**	
32.080.03	*Lupinus arboreus – Ericameria ericoides*			Y
Lupinus chamissonis – Ericameria ericoides				**Alliance**
32.160.00	**Silver dune lupine – mock heather scrub**	**G3**	**S3**	
32.160.01	*Ericameria ericoides*			Y
32.160.02	*Lupinus chamissonis*			Y
32.160.03	*Lupinus chamissonis – Ericameria ericoides*	G2	S2.2	Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Lycium californicum					**Alliance**
33.365.00	**California desert-thorn scrub**		**G4**	**S3**	
33.365.01	*Lycium californicum – Encelia californica*	Provisional			Y
33.365.02	*Lycium californicum*				Y
33.365.03	*Lycium californicum – Artemisia nesiotica*	Provisional			Y
Malacothamnus fasciculatus – Malacothamnus spp.					**Alliance**
45.450.00	**Bush mallow scrub**		**G4**	**S4**	
45.450.02	*Malacothamnus fasciculatus – Ceanothus megacarpus*		G3	S3	Y
45.450.03	*Malacothamnus fasciculatus – Ceanothus spinosus*		G3	S3	Y
45.450.05	*Malacothamnus fasciculatus – Salvia leucophylla*		G3	S3	Y
45.450.07	*Malacothamnus aboriginum*	Provisional			Y
Malosma laurina					**Alliance**
45.455.00	**Laurel sumac scrub**		**G4**	**S4**	
45.455.08	*Malosma laurina – Rhus ovata*		G3	S3	Y
Menodora spinescens					**Alliance**
33.290.00	**Spiny menodora scrub**		**G4**	**S3**	
33.290.01	*Menodora spinescens – Atriplex confertifolia*				Y
33.290.02	*Menodora spinescens – (Ephedra nevadensis)*				Y
Morella californica					**Alliance**
37.930.00	**Wax myrtle scrub**		**G3**	**S3**	
37.930.01	*Morella californica*				Y
Mortonia utahensis					**Alliance**
33.375.00	**Utah mortonia scrub**		**G4**	**S2**	
33.375.01	*Mortonia utahensis*				Y
Nolina (bigelovii, parryi)					**Alliance**
33.080.00	**Nolina scrub**		**G3**	**S2**	
33.080.01	*Nolina parryi*		GNR		Y
33.080.02	*Nolina bigelovii*				Y
Notholithocarpus densiflorus var. echinoides					**Alliance**
73.110.00	**Shrub tanoak chaparral**		**G3**	**S3**	
73.110.01	*Notholithocarpus densiflorus var. echinoides / Arctostaphylos nevadensis*				Y
73.110.02	*Notholithocarpus densiflorus var. echinoides / Pteridium aquilinum*				Y
Opuntia littoralis – Opuntia oricola – Cylindropuntia prolifera					**Alliance**
32.150.00	**Coast prickly pear scrub**		**G4**	**S3**	
32.150.01	*Opuntia littoralis – Eriogonum fasciculatum – Malosma laurina*				Y
32.150.02	*Opuntia littoralis*		G3	S3	Y
32.150.03	*Cylindropuntia prolifera – Mixed Coastal Scrub*	Provisional			Y
32.150.04	*Opuntia oricola*	Provisional			Y
Phyllodoce empetriformis		**Provisional**			**Alliance**
45.404.00	**Pink mountain-heath mats**		**G5**	**S2?**	

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Pluchea sericea					**Alliance**
63.710.00	**Arrow weed thickets**		**G4**	**S3**	
63.710.01	*Pluchea sericea Seasonally Flooded*				Y
Prunus fasciculata – Salazaria mexicana					**Alliance**
33.315.00	**Desert almond – Mexican bladdersage scrub**		**G4**	**S4**	
33.300.01	*Prunus fasciculata*		G4		Y
33.300.02	*Prunus fasciculata – Salazaria mexicana*				Y
33.300.03	*Prunus fasciculata – Rhus trilobata*				Y
33.300.04	*Prunus fasciculata – (Purshia stansburiana – Viguiera reticulata)*				Y
33.300.05	*Prunus fasciculata – Ambrosia eriocentra*				Y
33.310.01	*Salazaria mexicana*		GNR	SNR	Y
33.310.03	*Ambrosia salsola – Salazaria mexicana*	Provisional			Y
33.315.01	*Keckiella antirrhinoides – Prunus fasciculata*	Provisional			Y
33.315.02	*Prunus eremophila*	Provisional			Y
33.320.01	*Salvia dorrii Wash*		GNR		Y
Prunus fremontii					**Alliance**
33.220.00	**Desert apricot scrub**		**G4**	**S3**	
33.220.01	*Prunus fremontii*		G4		Y
Prunus ilicifolia – Heteromeles arbutifolia – Ceanothus spinosus					**Alliance**
37.912.00	**Holly leaf cherry – toyon – greenbark ceanothus chaparral**		**G5**	**S4**	
37.910.01	*Prunus ilicifolia ssp. Ilicifolia / Sanicula crassicaulis*		G2	S2?	Y
37.910.02	*Prunus ilicifolia ssp. ilicifolia – Heteromeles arbutifolia*		G3	S3	Y
37.910.03	*Prunus ilicifolia ssp. ilicifolia*				Y
37.910.04	*Prunus ilicifolia ssp. lyonii*				Y
37.910.05	*Prunus ilicifolia ssp. ilicifolia – Ceanothus cuneatus*				Y
37.910.06	*Prunus ilicifolia ssp. ilicifolia – Fraxinus dipetala*				Y
37.910.07	*Prunus ilicifolia ssp. ilicifolia – Toxicodendron diversilobum / grass*	Provisional			Y
37.911.01	*Heteromeles arbutifolia Serpentine*				Y
37.911.02	*Heteromeles arbutifolia – Artemisia californica*				Y
37.911.04	*Heteromeles arbutifolia – Fraxinus dipetala*	Provisional			Y
37.912.01	*Heteromeles arbutifolia*	Provisional			Y
Prunus virginiana		**Provisional**			**Alliance**
37.905.00	**Choke cherry thickets**		**G4**	**S2?**	
37.905.01	*Prunus virginiana*	Provisional			Y
37.905.02	*Prunus virginiana / Symphoricarpos rotundifolius*				Y
Psorothamnus fremontii – Psorothamnus polydenius					**Alliance**
61.590.00	**Fremont's smokebush – Nevada smokebush scrub**		**G4?**	**S3**	
61.590.01	*Psorothamnus polydenius var. polydenius / Achnatherum hymenoides*				Y
61.590.03	*Psorothamnus polydenius – (Psorothamnus arborescens)*				Y
61.590.04	*Psorothamnus arborescens*	Provisional			Y
61.590.05	*Psorothamnus arborescens – Atriplex confertifolia – Tetradymia spp.*				Y
61.590.06	*Sarcobatus baileyi*	Provisional			Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
Purshia stansburiana					**Alliance**
33.240.00	**Stansbury cliff rose scrub**		**G3**	**S3**	
33.240.01	*Purshia stansburiana*				Y
33.240.02	*Coleogyne ramosissima – Purshia stansburiana*				Y
33.240.03	*Purshia stansburiana – Agave utahensis*				Y
33.240.04	*Purshia stansburiana – Artemisia tridentata*				Y
Purshia tridentata – Artemisia tridentata					**Alliance**
35.200.00	**Bitter brush scrub**		**G4**	**S3**	
35.110.07	*Purshia glandulosa – Artemisia tridentata*				Y
35.200.02	*Purshia tridentata – Artemisia tridentata / Achnatherum hymenoides*		GNR		Y
35.200.03	*Purshia tridentata – Artemisia tridentata – Symphoricarpos rotundifolius*				Y
35.200.04	*Purshia tridentata / Achnatherum nelsonii*				Y
35.200.06	*Purshia glandulosa*				Y
35.200.07	*Purshia tridentata*	Provisional			Y
35.200.08	*Purshia tridentata – Artemisia tridentata – (Tetradymia canescens / Eriogonum umbellatum)*				Y
35.200.09	*Tetradymia canescens*	Provisional			Y
Quercus berberidifolia					**Alliance**
37.407.00	**Scrub oak chaparral**		**G4**	**S4**	
37.406.03	*Quercus berberidifolia – Ceanothus oliganthus*				Y
37.406.05	*Quercus berberidifolia – Ceanothus cuneatus*		G3	S3	Y
37.407.06	*Quercus berberidifolia – Cercocarpus montanus*		G3	S3	Y
37.407.07	*Quercus berberidifolia – Ceanothus spinosus*		G3	S3	Y
Quercus chrysolepis (shrub)					**Alliance**
37.413.00	**Canyon live oak chaparral**		**G3**	**S3**	
37.413.01	*Quercus chrysolepis*				Y
37.413.02	*Quercus chrysolepis – Ceanothus integerrimus*				Y
Quercus cornelius-mulleri					**Alliance**
37.415.00	**Muller oak chaparral**		**G4**	**S4**	
37.415.06	*Quercus cornelius-mulleri – Coleogyne ramosissima*		G3	S3.2	Y
Quercus dumosa – Quercus pacifica					**Alliance**
37.416.00	**Coastal sage and Island scrub oak chaparral**		**G3**	**S3**	
37.416.01	*Quercus pacifica*				Y
37.416.02	*Quercus pacifica – (Arctostaphylos insularis – Ceanothus megacarpus var. insularis)*				Y
37.416.03	*Quercus pacifica – Rhus integrifolia*				Y
37.416.04	*Quercus pacifica / grass*	Provisional			Y
37.416.05	*Quercus dumosa*	Provisional	G2	S2	Y
Quercus durata					**Alliance**
37.405.00	**Leather oak chaparral**		**G4**	**S4**	
37.405.01	*Quercus durata – Arctostaphylos glandulosa*		G3	S3	Y
37.405.06	*Quercus durata – Arctostaphylos glauca – Artemisia californica / Grass*	Provisional			Y

Primary Life form: Shrub

CaCode	Name		Rarity		Sensitive
37.405.07	*Quercus durata – Arctostaphylos glauca – Garrya congdonii / Melica torreyana*	Provisional	G3	S3	Y
37.405.08	*Quercus durata – Arctostaphylos pungens / Pinus sabiniana*		G2	S2	Y
37.405.12	*Quercus durata – Frangula californica ssp. tomentella – Arctostaphylos glauca*	Provisional			Y
37.405.13	*Quercus durata / Allium falcifolium – Streptanthus batrachopus*		G2	S2?	Y
37.405.14	*Quercus durata – Adenostoma fasciculatum / Salvia sonomensis*				Y
37.405.15	*Quercus durata – Adenostoma fasciculatum*	Provisional			Y
37.405.16	*Quercus durata – Ceanothus jepsonii*				Y
Quercus john-tuckeri					**Alliance**
37.418.00	**Tucker oak chaparral**		**G4**	**S4**	
37.418.01	*Quercus john-tuckeri – Adenostoma fasciculatum*		G3	S3	Y
37.418.02	*Quercus john-tuckeri – Juniperus californica – Fraxinus dipetala*		G3	S3	Y
37.418.03	*Quercus john-tuckeri – Quercus wislizeni – Garrya flavescens*		G3	S3	Y
37.418.05	*Quercus john-tuckeri – Juniperus californica – Ericameria linearifolia*		G3	S3	Y
Quercus palmeri					**Alliance**
37.419.00	**Palmer oak chaparral**		**G3**	**S2?**	
37.419.01	*Quercus palmeri – Eriogonum fasciculatum*				Y
37.419.02	*Quercus palmeri – Eriogonum wrightii*				Y
Quercus sadleriana					**Alliance**
37.412.00	**Sadler oak or deer oak brush fields**		**G3**	**S3**	
37.412.01	*Quercus sadleriana*	Provisional			Y
Quercus turbinella					**Alliance**
71.095.00	**Sonoran live oak scrub**		**G4**	**S1**	
71.095.02	*Quercus turbinella – Baccharis sergiloides*				Y
Quercus wislizeni (shrub)					**Alliance**
37.420.00	**Interior live oak chaparral**		**G4**	**S4**	
37.420.01	*Quercus wislizeni var. frutescens*		G3	S3?	Y
37.420.02	*Quercus wislizeni – Arctostaphylos glandulosa*		G3	S3?	Y
Rhododendron columbianum					**Alliance**
63.425.00	**Western Labrador-tea thickets**		**G4**	**S2?**	
63.425.01	*Rhododendron columbianum*				Y
87.080.08	*Rhododendron columbianum / Pinus contorta ssp. murrayana*		G3		Y
Rhododendron occidentale		**Provisional**			**Alliance**
63.310.00	**Western azalea patches**		**G3**	**S2?**	
Rhus integrifolia					**Alliance**
37.803.00	**Lemonade berry scrub**		**G3**	**S3**	
37.803.01	*Rhus integrifolia*		G3	S3	Y
37.803.02	*Rhus integrifolia – Adenostoma fasciculatum – Artemisia californica*				Y
37.803.03	*Rhus integrifolia – Artemisia californica – Eriogonum cinereum*		G3	S3	Y
37.803.04	*Rhus integrifolia – Opuntia spp. – Eriogonum cinereum*		G3	S3	Y
37.803.05	*Rhus integrifolia – Artemisia californica – Salvia mellifera*				Y

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CaCode	Name		Rarity		Sensitive
37.803.06	*Rhus integrifolia – Artemisia californica*	Provisional			Y
37.803.07	*Rhamnus pirifolia*	Provisional			Y
Rhus ovata					**Alliance**
37.801.00	**Sugarbush chaparral**		**G4**	**S4**	
37.801.01	*Rhus ovata*		G3	S3	Y
37.801.02	*Rhus ovata – Salvia leucophylla – Artemisia californica*		G3	S3	Y
37.801.03	*Rhus ovata – Ziziphus parryi*				Y
Rhus trilobata – Crataegus rivularis – Forestiera pubescens					**Alliance**
61.580.00	**Basket bush – river hawthorn – desert olive patches**		**G4**	**S3?**	
37.802.01	*Rhus trilobata*		G3	S3	Y
61.580.01	*Forestiera pubescens*	Provisional	G1G2	S1S2	Y
61.580.02	*Forestiera pubescens – Sambucus nigra*				Y
Ribes quercetorum		**Provisional**			**Alliance**
37.960.00	**Oak gooseberry thickets**		**G2**	**S2?**	
37.960.01	*Ribes quercetorum*	Provisional			Y
Rosa californica					**Alliance**
63.907.00	**California rose briar patches**		**G3**	**S3**	
63.907.01	*Rosa californica – Baccharis pilularis*				Y
63.907.02	*Rosa californica*				Y
63.907.03	*Rosa californica / Schoenoplectus spp.*				Y
Rubus (parviflorus, spectabilis, ursinus)					**Alliance**
63.901.00	**Coastal brambles**		**G4**	**S3**	
63.901.01	*Gaultheria shallon – Rubus spectabilis – Rubus parviflorus*				Y
63.901.02	*Rubus parviflorus – Rubus spectabilis – Rubus ursinus*				Y
63.901.03	*Rubus parviflorus*				Y
63.901.04	*Rubus spectabilis*		G4	S2.2?	Y
63.901.05	*Rubus ursinus*				Y
63.901.06	*Ribes aureum*	Provisional			Y
Salix boothii – Salix geyeriana – Salix lutea					**Alliance**
61.218.00	**Booth' s Willow – Geyer's Willow – Yellow Willow thickets**		**GNR**	**S2**	
61.204.02	*Salix lucida / Poa pratensis*				Y
61.204.05	*Salix lucida ssp. lasiandra / Equisetum arvense*				Y
61.204.06	*Salix lucida ssp. lasiandra / Trifolium longipes*				Y
61.210.01	*Salix lutea / mesic forbs*				Y
61.210.02	*Salix lutea / mesic graminoids*				Y
61.210.03	*Salix lutea / Poa pratensis*				Y
61.210.04	*Salix lutea / Rosa woodsii*				Y
61.212.01	*Salix geyeriana / grass*				Y
61.212.02	*Salix geyeriana / mesic graminoid*				Y
61.213.01	*Salix bebbiana / mesic forb*				Y
Salix breweri					**Alliance**
61.215.00	**Brewer willow thickets**		**G2**	**S2**	
61.215.01	*Salix breweri / Muhlenbergia asperifolia*		G2	S2	Y

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CaCode	Name		Rarity		Sensitive
61.215.02	*Salix breweri*	Provisional			Y
Salix eastwoodiae					**Alliance**
61.112.00	**Sierran willow thickets**		**G3**	**S3**	
61.112.01	*Salix eastwoodiae*		G2Q		Y
61.112.02	*Salix eastwoodiae / Carex scopulorum*				Y
61.112.03	*Salix eastwoodiae / Oreostemma alpigenum*				Y
63.160.02	*Salix eastwoodiae / Senecio triangularis*				Y
Salix exigua					**Alliance**
61.209.00	**Sandbar willow thickets**		**G5**	**S4**	
61.209.06	*Salix exigua – Brickellia californica*				Y
Salix hookeriana					**Alliance**
61.203.00	**Coastal dune willow thickets**		**G4**	**S3**	
61.203.01	*Salix hookeriana*				Y
61.203.02	*Salix hookeriana / Rubus ursinus*				Y
Salix jepsonii					**Alliance**
61.118.00	**Jepson willow thickets**		**G3**	**S3**	
61.118.01	*Salix jepsonii*				Y
61.118.02	*Salix jepsonii / Senecio triangularis*				Y
61.118.03	*Salix jepsonii – Paxistima myrsinites*				Y
61.118.04	*Salix jepsonii – Cornus sericea*				Y
Salix lasiolepis					**Alliance**
61.201.00	**Arroyo willow thickets**		**G4**	**S4**	
61.201.01	*Salix lasiolepis*				Y
61.201.04	*Salix lasiolepis – Salix lucida*		G3	S3?	Y
61.201.05	*Salix lasiolepis – Baccharis pilularis – Rubus ursinus*		G3	S3	Y
61.201.07	*Salix lasiolepis – Malosma laurina*		G3	S3?	Y
61.201.09	*Salix lasiolepis / Barren Ground*				Y
61.201.10	*Salix lasiolepis / Rosa woodsii / Mixed Herbs*				Y
Salix lemmonii					**Alliance**
61.113.00	**Lemmon’s willow thickets**		**G4**	**S3**	
61.113.01	*Salix lemmonii*	Provisional			Y
61.113.02	*Salix lemmonii / Carex spp.*				Y
61.113.03	*Salix lemmonii / mesic graminoid*				Y
61.113.04	*Salix lemmonii / mesic forb*				Y
61.113.05	*Salix lemmonii / fluvent*				Y
61.113.06	*Salix lemmonii / dry graminoid*				Y
Salix nivalis		**Provisional**			**Alliance**
91.127.00	**Snow willow mats**		**G4**	**S1?**	
Salix orestera					**Alliance**
61.115.00	**Sierra gray willow thickets**		**G4**	**S4**	
63.160.03	*Salix orestera / Allium validum*				Y

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CaCode	Name		Rarity		Sensitive
Salix petrophila					**Alliance**
61.116.00	**Alpine willow turf**		**G5**	**S3**	
61.116.01	*Salix petrophila*	Provisional			Y
61.116.02	*Salix petrophila – Calamagrostis muiriana – Vaccinium cespitosum – Antennaria media*		G3?		Y
61.116.03	*Salix petrophila – Calamagrostis muiriana*				Y
Salix planifolia		**Provisional**			**Alliance**
61.119.00	**Tea-leaved willow thickets**		**G4**	**S2?**	
61.119.01	*Salix planifolia*	Provisional			Y
61.119.02	*Salix planifolia/Carex scopulorum*	Provisional			Y
Salix sitchensis		**Provisional**			**Alliance**
61.206.00	**Sitka willow thickets**		**G4**	**S3?**	
61.206.01	*Salix sitchensis*	Provisional			Y
Salvia apiana					**Alliance**
32.030.00	**White sage scrub**		**G4**	**S3**	
32.030.01	*Salvia apiana – Artemisia californica*				Y
32.030.02	*Salvia apiana – Encelia farinosa*				Y
32.030.03	*Salvia apiana – Hesperoyucca whipplei*				Y
32.030.04	*Salvia apiana*	Provisional	G3	S3	Y
Salvia leucophylla					**Alliance**
32.090.00	**Purple sage scrub**		**G4**	**S4**	
32.090.04	*Artemisia californica – Salvia leucophylla – Eriogonum cinereum / Nassella spp.*		G3	S3	Y
32.090.05	*Salvia leucophylla – Eriogonum cinereum / annual herb*		G3	S3	Y
Salvia mellifera					**Alliance**
32.020.00	**Black sage scrub**		**G4**	**S4**	
32.020.07	*Salvia mellifera – Eriogonum fasciculatum var. foliolosum – Eriodictyon tomentosum*		G3	S3	Y
32.020.08	*Salvia mellifera – Eriogonum cinereum*		G3	S3	Y
32.020.11	*Salvia mellifera – Rhus ovata*		G3	S3?	Y
32.020.14	*Salvia mellifera – Opuntia littoralis – Rhus integrifolia*				Y
45.450.06	*Salvia mellifera – Malacothamnus fasciculatus*		G3	S3	Y
Sambucus nigra					**Alliance**
63.410.00	**Blue elderberry stands**		**G3**	**S3**	
63.410.01	*Sambucus nigra*				Y
63.410.02	*Sambucus nigra / Leymus condensatus*		G3	S3?	Y
63.410.03	*Sambucus nigra – Heteromeles arbutifolia*		G3	S3	Y
Sarcobatus vermiculatus					**Alliance**
36.400.00	**Greasewood scrub**		**G5**	**S4**	
35.331.01	*Chrysothamnus albidus*	Provisional	G4	S1	Y
36.220.01	*Atriplex parryi*	Provisional	G3	S2	Y
36.400.02	*Sarcobatus vermiculatus – Atriplex confertifolia – (Picrothamnus desertorum, Suaeda moquinii)*				Y

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CaCode	Name		Rarity		Sensitive
36.400.03	*Sarcobatus vermiculatus / Leymus cinereus*				Y
36.400.04	*Sarcobatus vermiculatus / Distichlis spicata*				Y
36.400.05	*Sarcobatus vermiculatus / Sporobolus airoides*				Y
36.400.07	*Sarcobatus vermiculatus – Suaeda moquinii*				Y
Senegalia greggii – Hyptis emoryi – Justicia californica					**Alliance**
33.045.00	**Catclaw acacia – desert lavender – chuparosa scrub**		**G4**	**S4**	
33.040.11	*Senegalia greggii / Eriogonum davidsonii*				Y
33.045.01	*Senegalia greggii – (Ambrosia eriocentra – Salvia dorrii)*				Y
33.045.02	*Senegalia greggii – (Bebbia juncea – Hyptis emoryi)*				Y
33.190.01	*Hyptis emoryi*		G4	S3	Y
33.340.01	*Justicia californica*	Provisional			Y
Simmondsia chinensis		**Provisional**			**Alliance**
33.005.00	**Jojoba scrub**		**G4**	**S3?**	
33.005.01	*Simmondsia chinensis – Eriogonum fasciculatum – Cylindropuntia californica*	Provisional			Y
Suaeda moquinii					**Alliance**
36.200.00	**Bush seepweed scrub**		**G4**	**S3**	
36.200.01	*Suaeda moquinii*		G5		Y
36.200.03	*Suaeda moquinii – Atriplex canescens*				Y
36.200.04	*Suaeda moquinii / Lepidium dictyotum*				Y
36.210.01	*Isocoma acradenia Alkaline Wet*		G3	S3	Y
36.210.02	*Isocoma acradenia – Suaeda moquinii*		G3		Y
Tetracoccus hallii		**Provisional**			**Alliance**
33.350.00	**Hall's shrubby-spurge patches**		**G2**	**S1**	
Toxicodendron diversilobum					**Alliance**
37.940.00	**Poison oak scrub**		**G4**	**S4**	
37.940.01	*Toxicodendron diversilobum – Baccharis pilularis – Rubus parviflorus*		G3	S3?	Y
37.940.02	*Toxicodendron diversilobum – Artemisia californica / Leymus condensatus*		G3	S3	Y
37.940.03	*Toxicodendron diversilobum – Diplacus aurantiacus*		G3	S3?	Y
Vaccinium cespitosum					**Alliance**
45.405.00	**Dwarf bilberry meadows and mats**		**G4?**	**S3?**	
45.400.02	*Vaccinium cespitosum – Carex nigricans*				Y
45.405.02	*Vaccinium cespitosum – Kalmia microphylla*				Y
45.405.03	*Vaccinium cespitosum – Calamagrostis muiriana*				Y
45.405.04	*Vaccinium cespitosum – Carex filifolia*				Y
Vaccinium uliginosum					**Alliance**
45.410.00	**Bog blueberry wet meadows**		**G4**	**S3**	
45.410.01	*Vaccinium uliginosum*		G2G3 ?		Y
45.410.02	*Vaccinium uliginosum ssp. occidentale / Bistorta bistortoides*				Y
45.410.03	*Vaccinium uliginosum / Aulacomnium palustre*				Y
45.410.04	*Vaccinium uliginosum / Sphagnum teres*				Y

Primary Life form: Shrub

CaCode	Name	Rarity		Sensitive
Venegasia carpesioides				**Alliance**
39.030.00	**Canyon sunflower scrub**	**G3**	**S3**	
39.030.01	*Venegasia carpesioides*			Y
Vitis arizonica – Vitis girdiana				**Alliance**
63.540.00	**Wild grape shrubland**	**G3**	**S3**	
63.430.01	*Vitis californica*	G3	S3	Y
63.430.02	*Vitis girdiana*	G3	S3	Y
Xylococcus bicolor				**Alliance**
37.109.00		**G4**	**S3**	
37.109.01	*Adenostoma fasciculatum – Xylococcus bicolor*			Y
37.109.02	*Adenostoma fasciculatum – Xylococcus bicolor – Ceanothus tomentosus*			Y
37.109.05	*Adenostoma fasciculatum – Xylococcus bicolor – Ceanothus crassifolius*			Y
37.109.08	*Adenostoma fasciculatum – Xylococcus bicolor – Ceanothus verrucosus*			Y
37.109.09	*Adenostoma fasciculatum – Xylococcus bicolor – Cneoridium dumosum*			Y
37.109.10	*Adenostoma fasciculatum – Xylococcus bicolor – Eriogonum fasciculatum*			Y
37.109.11	*Xylococcus bicolor – Rhus integrifolia*			Y
37.109.12	*Adenostoma fasciculatum – Xylococcus bicolor – Quercus berberidifolia*			Y
37.109.13	*Adenostoma fasciculatum – Xylococcus bicolor – Salvia mellifera – Malosma laurina*			Y
37.109.14	*Adenostoma fasciculatum – Xylococcus bicolor – Ceanothus crassifolius – Malosma laurina*			Y
Yucca schidigera				**Alliance**
33.070.00	**Mojave yucca scrub**	**G4**	**S4**	
33.070.08	*Yucca schidigera – Cylindropuntia acanthocarpa*			Y
33.070.11	*Yucca schidigera – Larrea tridentata – Agave deserti*			Y
33.070.12	*Yucca schidigera / Pleuraphis rigida*	G3	S3	Y
Ziziphus obtusifolia				**Special Stands**
33.225.00	**Graythorn patches**	**G2**	**S2?**	

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Abronia latifolia – Ambrosia chamissonis					**Alliance**
21.100.00	**Dune mat**		**G3**	**S3**	
21.100.01	*Artemisia pycnocephala – Calystegia soldanella*				Y
21.100.03	*Ambrosia chamissonis – Eriophyllum staechadifolium – (Lupinus arboreus)*				Y
21.100.06	*Poa douglasii – Lathyrus littoralis*				Y
21.100.11	*Ambrosia chamissonis*	Provisional			Y
21.101.01	*Abronia latifolia – Erigeron glaucus*				Y
21.101.02	*Abronia latifolia – Leymus mollis*				Y
21.102.01	*Ambrosia chamissonis – Abronia umbellata*				Y
21.102.02	*Ambrosia chamissonis – Abronia maritima – Cakile maritima*				Y
21.102.03	*Ambrosia chamissonis – Malacothrix incana – Carpobrotus chilensis – Poa douglasii*				Y
21.102.04	*Cakile maritima – Ambrosia chamissonis – Carpobrotus edulis*				Y
21.102.05	*Calystegia macrostegia – Erigeron glaucus – Malacothrix incana*				Y
21.110.01	*Artemisia pycnocephala – Cardionema ramosissimum*		G3	S3?	Y
21.110.02	*Artemisia pycnocephala – Polygonum paronychia*				Y
21.110.03	*Artemisia pycnocephala – Ericameria ericoides*				Y
21.110.04	*Artemisia pycnocephala – Poa douglasii*				Y
21.125.01	*Cakile maritima – Abronia maritima*	Provisional			Y
Achnatherum hymenoides					**Alliance**
41.120.00	**Indian rice grass grassland**		**G4**	**S1**	
41.120.01	*Achnatherum hymenoides – Linanthus pungens*				Y
41.120.02	*Achnatherum hymenoides – Oenothera deltoides*				Y
41.120.03	*Achnatherum hymenoides Shrub*				Y
Achnatherum speciosum					**Alliance**
41.090.00	**Desert needlegrass grassland**		**G4**	**S2**	
41.090.01	*Achnatherum speciosum Shrub*				Y
Alopecurus geniculatus		**Provisional**			**Alliance**
42.006.00	**Water foxtail meadows**		**G3?**	**S3?**	
Amsinckia (menziesii, tessellata) – Phacelia spp.					**Alliance**
42.110.00	**Fiddleneck - Phacelia Fields**		**G5**	**S5**	
42.110.04	*Phacelia tanacetifolia*				Y
42.110.06	*Phacelia ciliata*	Provisional			Y
42.110.07	*Astragalus didymocarpus – Lotus wrangelianus*				Y
Anemopsis californica – Helianthus nuttallii – Solidago spectabilis					**Alliance**
52.214.00	**Yerba mansa – Nuttall's sunflower – Nevada goldenrod alkaline wet me**		**G3**	**S2**	
52.214.01	*Anemopsis californica – Juncus arcticus var. mexicanus*				Y
52.214.02	*Anemopsis californica*	Provisional			Y
52.214.03	*Solidago (confinis, spectabilis)*	Provisional			Y
52.214.04	*Helianthus nuttallii*	Provisional			Y
Argentina egedii					**Alliance**
38.140.00	**Pacific silverweed marshes**		**G4**	**S2**	

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
38.140.01	*Argentina egedii*				Y
38.140.02	*Argentina egedii – Alopecurus aequalis*				Y
38.140.03	*Argentina egedii – Eleocharis macrostachya*				Y
38.140.04	*Argentina egedii – Lotus uliginosus*				Y
Aristida purpurea – Elymus elymoides – Poa secunda					**Alliance**
41.660.00	**Purple three-awn – squirreltail – curly blue grass patches**		**G4**	**S4?**	
41.180.05	*Monolopia stricta – Poa secunda*				Y
41.180.06	*Poa secunda – Bromus rubens*				Y
41.650.01	*Elymus multisetus – Plantago erecta – Lolium perenne*	Provisional			Y
41.650.02	*Elymus multisetus – (Eschscholzia californica – Plantago erecta)*	Provisional			Y
41.660.01	*Poa secunda – (Elymus sp.) – Clarkia cylindrica*				Y
41.660.03	*Aristida purpurea*	Provisional			Y
Arthrocnemum subterminale					**Alliance**
52.212.00	**Parish's glasswort patches**		**G4**	**S2**	
52.212.01	*Arthrocnemum subterminale*	Provisional			Y
52.212.02	*Arthrocnemum subterminale – Sarcocornia pacifica*		G3		Y
52.212.03	*Arthrocnemum subterminale – Monanthochloe littoralis*				Y
Bistorta bistortoides – Mimulus primuloides					**Alliance**
45.413.00	**Western bistort – primrose monkey flower meadows**		**G4**	**S4**	
45.413.01	*Bistorta bistortoides – Mimulus primuloides*				Y
45.413.03	*Mimulus primuloides*				Y
Bolboschoenus maritimus					**Alliance**
52.112.00	**Salt marsh bulrush marshes**		**G4**	**S3**	
52.112.03	*Bolboschoenus maritimus*				Y
52.112.04	*Bolboschoenus maritimus – Sarcocornia pacifica*				Y
52.112.05	*Bolboschoenus maritimus / Sesuvium verrucosum*				Y
Bromus carinatus – Elymus glaucus					**Alliance**
41.131.00	**California brome – blue wildrye prairie**		**G3**	**S3**	
41.131.01	*Bromus carinatus*		G3	S3	Y
41.131.02	*Pteridium aquilinum – Grass*		G3	S3	Y
41.131.03	*Thermopsis californica – Bromus carinatus – Annual Brome*		G3	S3	Y
41.640.01	*Elymus glaucus*	Provisional	G3	S3	Y
Calamagrostis canadensis					**Alliance**
41.224.00	**Bluejoint reed grass meadows**		**G5**	**S3**	
41.224.01	*Calamagrostis canadensis*		G4	S3?	Y
41.224.02	*Calamagrostis canadensis – Carex utriculata*				Y
41.224.03	*Calamagrostis canadensis – Dodecatheon redolens*				Y
41.224.04	*Calamagrostis canadensis – Scirpus microcarpus*				Y
Calamagrostis nutkaensis					**Alliance**
41.190.00	**Pacific reed grass meadows**		**G4**	**S2**	
41.190.01	*Calamagrostis nutkaensis / Baccharis pilularis*		G2	S1.2	Y
41.190.02	*Calamagrostis nutkaensis – Carex (obnupta) – Juncus (patens)*		G2	S2.1	Y
41.190.03	*Calamagrostis nutkaensis*				Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Calamagrostis scopulorum – Andropogon glomeratus					**Alliance**
41.195.00	**Ditch reedgrass – bushy bluestem saturated hanging garden**		**G1**	**S1**	
41.195.01	*Andropogon glomeratus – Schoenus nigricans*		G1	S1	Y
Camassia quamash					**Alliance**
45.416.00	**Small camas meadows**		**G4?**	**S3?**	
45.416.01	*Camassia quamash / Sphagnum subsecundum*				Y
Carex (aquatilis, lenticularis)					**Alliance**
45.168.00	**Water sedge and lakeshore sedge meadows**		**G5**	**S3**	
45.168.01	*Carex aquatilis*				Y
45.168.02	*Carex lenticularis / Aulacomnium palustre*				Y
45.168.03	*Carex lenticularis / Perideridia parishii*				Y
45.168.04	*Carex aquatilis – Carex lenticularis*				Y
Carex (pansa, praegracilis)					**Alliance**
45.184.00	**Sand dune sedge swaths**		**G4?**	**S3?**	
45.184.01	*Carex pansa*	Provisional			Y
45.184.02	*Carex pansa – Baccharis pilularis*	Provisional			Y
45.184.03	*Carex praegracilis*	Provisional			Y
Carex barbarae					**Alliance**
45.142.00	**White-root beds**		**G2?**	**S2?**	
45.142.01	*Carex barbarae*				Y
Carex breweri					**Alliance**
45.150.00	**Brewer sedge mats**		**G4**	**S3**	
45.150.01	*Carex breweri*		G3?		Y
45.150.02	*Carex breweri – Poa wheeleri*				Y
45.150.03	*Carex breweri – Cistanthe umbellata*				Y
Carex congdonii		**Provisional**			**Alliance**
45.160.00	**Congdon's sedge talus**		**G2**	**S2**	
45.160.01	*Arnica amplexicaulis – Carex congdonii*	Provisional			Y
Carex densa		**Provisional**			**Alliance**
45.165.00	**Dense sedge marshes**		**G2?**	**S2?**	
45.165.02	*Carex densa – Juncus xiphioides*	Provisional			Y
45.165.03	*Carex densa – Lolium perenne – Juncus spp.*	Provisional			Y
Carex echinata					**Alliance**
45.191.00	**Star sedge fens**		**G4?**	**S3?**	
45.191.01	*Carex echinata / (Philonotis fontana – Sphagnum subsecundum)*				Y
Carex filifolia					**Alliance**
45.140.00	**Shorthair sedge turf**		**G4**	**S4**	
45.140.06	*Carex filifolia*		G3?		Y
Carex helleri					**Alliance**
45.145.00	**Heller's sedge fell-fields**		**G4**	**S2**	
45.145.03	*Carex helleri – Saxifraga tolmiei – Luzula divaricata*				Y
45.145.04	*Carex helleri – Poa suksdorfii*				Y

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CaCode	Name		Rarity		Sensitive
45.145.05	*Carex helleri – Eriogonum incanum – Raillardella argentea*				Y
45.145.06	*Carex helleri – Arabis platysperma – Penstemon heterodoxus*				Y
Carex heteroneura		**Provisional**			**Alliance**
45.115.00	**Different-nerve sedge patches**		**G3?**	**S3?**	
45.115.01	*Carex heteroneura – Achillea millefolium*	Provisional			Y
Carex integra		**Provisional**			**Alliance**
45.175.00	**Small-fruited sedge meadows**		**G4?**	**S2?**	
45.175.01	*Carex integra*	Provisional			Y
45.175.02	*Carex integra – Poa cusickii*	Provisional			Y
Carex jonesii					**Alliance**
45.162.00	**Jones's sedge turf**		**G4**	**S3**	
45.162.01	*Carex jonesii – Bistorta bistortoides*				Y
45.162.02	*Carex jonesii*				Y
45.162.03	*Carex jonesii / Sphagnum subsecundum*				Y
Carex lasiocarpa		**Provisional**			**Alliance**
45.166.00	**Slender sedge meadows**		**G5?**	**S3?**	
45.166.01	*Carex lasiocarpa*				Y
Carex limosa					**Alliance**
45.178.00	**Shore sedge fens**		**G4?**	**S2?**	
45.110.03	*Carex limosa – Mimulus primuloides*				Y
45.178.01	*Carex limosa / Drepanocladus sordidus*				Y
45.178.02	*Carex limosa – Menyanthes trifoliata*				Y
Carex luzulina		**Provisional**			**Alliance**
45.179.00	**Woodland sedge fens**		**G3**	**S2?**	
45.179.01	*Carex luzulina – Philonotis fontana*	Provisional			Y
Carex microptera		**Provisional**			**Alliance**
45.181.00	**Small-winged sedge meadows**		**G4**	**S2?**	
45.181.01	*Carex microptera*	Provisional			Y
Carex nigricans		**Provisional**			**Alliance**
45.164.00	**Black alpine sedge meadows**		**G4**	**S3?**	
45.164.02	*Carex nigricans – Kalmia microphylla*	Provisional			Y
Carex nudata					**Alliance**
45.182.00	**Torrent sedge patches**		**G3**	**S3**	
45.182.01	*Carex nudata*				Y
Carex obnupta					**Alliance**
45.183.00	**Slough sedge swards**		**G4**	**S3**	
45.183.01	*Carex obnupta*				Y
45.183.02	*Carex obnupta – Juncus lescurii*				Y
45.183.03	*Carex obnupta – Juncus patens*		G3	S3?	Y
Carex scopulorum					**Alliance**
45.120.00	**Sierra alpine sedge turf**		**G4**	**S3**	
45.120.01	*Carex scopulorum*		G5		Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
45.120.02	*Carex scopulorum – Pedicularis groenlandica*				Y
45.120.03	*Carex scopulorum – Eriophorum crinigerum*				Y
45.120.04	*Carex scopulorum – Eleocharis quinqueflora*				Y
45.120.05	*Carex scopulorum / Oreostemma alpigenum*				Y
45.120.06	*Carex scopulorum / Aulacomnium palustre*				Y
45.120.07	*Carex scopulorum – Allium validum*				Y
45.120.08	*Carex scopulorum – Mimulus primuloides*				Y
Carex serratodens		**Provisional**			**Alliance**
45.180.00	**Twotooth sedge seeps**		**G3**	**S3?**	
45.180.03	*Carex serratodens*	Provisional			Y
Carex simulata					**Alliance**
45.190.00	**Short-beaked sedge meadows**		**G4**	**S3**	
45.190.01	*Carex simulata*				Y
45.190.02	*Carex simulata / Aulacomnium palustre*				Y
45.190.03	*Carex simulata / Philonotis fontana*				Y
45.190.04	*Carex simulata – Carex utriculata*				Y
45.190.05	*Carex simulata – Carex vesicaria*				Y
Carex spectabilis					**Alliance**
45.155.00	**Showy sedge sod**		**G4**	**S3**	
45.155.01	*Carex spectabilis – Sibbaldia procumbens*		G3?		Y
45.155.02	*Carex spectabilis – Senecio triangularis*				Y
Carex straminiformis		**Provisional**			**Alliance**
45.185.00	**Mount Shasta sedge meadows**		**G3?**	**S3?**	
45.185.01	*Carex straminiformis*	Provisional			Y
45.185.02	*Achnatherum lemmonii – Carex straminiformis*	Provisional			Y
Carex subnigricans					**Alliance**
45.186.00	**Dark alpine sedge turf**		**G4**	**S3**	
45.110.22	*Carex vernacula – Antennaria media*				Y
45.186.01	*Carex subnigricans – Antennaria media*				Y
45.186.02	*Carex subnigricans – Oreostemma alpigenum*				Y
45.186.03	*Carex subnigricans – Dodecatheon alpinum*				Y
45.186.04	*Carex subnigricans – Pedicularis attollens*				Y
45.186.05	*Carex subnigricans – Deschampsia cespitosa*				Y
Centromadia (pungens)					**Alliance**
44.160.00	**Tar plant fields**		**G2**	**S2**	
44.160.01	*Centromadia pungens ssp. laevis*				Y
44.160.02	*Centromadia pungens – Downingia bella*				Y
44.160.03	*Centromadia pungens – Lepidium dictyotum*				Y
Chorizanthe rigida – Geraea canescens Desert Pavement					**Alliance**
22.310.00	**Rigid spineflower – hairy desert sunflower**		**G4**	**S4**	
22.310.01	*Chorizanthe brevicornu – Stephanomeria pauciflora*	Provisional			Y
33.380.01	*Chorizanthe rigida – Geraea canescens Desert Pavement*			SNR	Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Cirsium fontinale					**Alliance**
42.100.00	**Fountain thistle seeps**		**G1**	**S1**	
42.100.01	*Cirsium fontinale var. campylon – Carex serratodens – Hordeum brachyantherum*				Y
42.100.02	*Cirsium fontinale var. campylon – Hemizonia congesta ssp. luzulifolia*				Y
42.100.03	*Cirsium fontinale var. campylon – Mimulus guttatus – Stachys pycnantha*				Y
Cladium californicum		**Provisional**			**Alliance**
52.160.00	**California sawgrass alkaline seep**		**G4**	**S1**	
52.160.01	*Cladium californicum*	Provisional	G4	S1	Y
Corethrogyne filaginifolia – Eriogonum (elongatum, nudum)					**Alliance**
32.230.00	**Sand-aster and perennial buckwheat fields**		**G4**	**S4**	
32.230.01	*Eriogonum elongatum*				Y
32.230.03	*Eriogonum nudum var. indictum – Eriogonum vestitum*		G2	S2	Y
32.230.05	*Lupinus excubitus – Mentzelia albicaulis – Eriogonum spp.*				Y
Cressa truxillensis – Distichlis spicata					**Alliance**
46.100.00	**Alkali weed – salt grass playas and sinks**		**G2**	**S2**	
46.100.01	*Atriplex persistens*				Y
46.100.02	*Chamaesyce hooveri – Bolboschoenus maritimus*	Provisional			Y
46.100.03	*Neostapfia colusana – Malvella leprosa*	Provisional			Y
46.100.04	*Neostapfia colusana – Polypogon maritimus*	Provisional			Y
46.100.05	*Orcuttia pilosa*	Provisional			Y
46.100.06	*Tuctoria greenei – Marsilea vestita*	Provisional			Y
46.100.07	*Tuctoria mucronata*	Provisional			Y
46.100.08	*Cressa truxillensis – Distichlis spicata*	Provisional			Y
46.100.09	*Cressa truxillensis*	Provisional			Y
46.100.10	*Plagiobothrys parishii – Distichlis spicata*	Provisional			Y
Danthonia californica					**Alliance**
41.050.00	**California oat grass prairie**		**G4**	**S3**	
41.050.01	*Danthonia californica – Arrhenatherum elatius*				Y
41.050.02	*Danthonia californica – Elymus elymoides*				Y
41.050.03	*Danthonia californica – Muhlenbergia filiformis*				Y
41.050.04	*Danthonia californica – Aira caryophyllea*		G3	S2?	Y
41.050.05	*Danthonia californica*				Y
41.050.06	*Danthonia californica – (Briza maxima – Vulpia bromoides)*				Y
41.050.07	*Danthonia californica – Nassella pulchra*				Y
Danthonia intermedia		**Provisional**			**Alliance**
41.051.00	**Wild mountain oat grass meadows**		**G4?**	**S3?**	
41.051.01	*Danthonia intermedia – Antennaria rosea*	Provisional	G4?		Y
41.051.02	*Danthonia intermedia – Ptilagrostis kingii*	Provisional			Y
41.051.03	*Danthonia unispicata – Ptilagrostis kingii – Senecio scorzonella*	Provisional			Y
Darlingtonia californica					**Alliance**
51.200.00	**California pitcher plant fens**		**G4?**	**S3**	
51.200.01	*Darlingtonia californica*				Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Deinandra fasciculata					**Alliance**
44.161.00	**Clustered tarweed fields**		**G2**	**S2**	
44.161.01	*Deinandra fasciculata – annual grass-herb*				Y
44.161.02	*Deinandra fasciculata – Hordeum depressum – Atriplex coronata var. notatior*				Y
Deschampsia cespitosa					**Alliance**
41.220.00	**Tufted hair grass meadows**		**G5**	**S4?**	
41.220.01	*Deschampsia cespitosa – Carex nebrascensis*		G3?Q		Y
41.220.02	*Deschampsia cespitosa – Cardamine breweri*				Y
41.220.05	*Deschampsia cespitosa – Anthoxanthum odoratum*				Y
41.220.08	*Deschampsia cespitosa*		G4		Y
41.220.09	*Deschampsia cespitosa – Danthonia californica*		G2	S2	Y
41.220.10	*Deschampsia cespitosa – Trifolium longipes*				Y
41.220.12	*Deschampsia cespitosa – Bistorta bistortoides*		G3?		Y
41.220.13	*Deschampsia cespitosa – Horkelia marinensis*		G3	S1?	Y
41.220.14	*Deschampsia cespitosa – Lilaeopsis masonii*	Provisional			Y
41.220.15	*Deschampsia cespitosa var. holciformis*				Y
41.220.16	*Deschampsia cespitosa – Holcus lanatus*				Y
41.220.17	*Deschampsia cespitosa – Eryngium armatum*				Y
Dicoria canescens – Abronia villosa – Panicum urvilleanum					**Alliance**
22.105.00	**Mojave-Sonoran desert dunes**		**G4**	**S3**	
22.100.01	*Dicoria canescens*				Y
22.105.01	*Rumex hymenosepalus*	Provisional	G2	S2	Y
22.105.02	*Oenothera deltoides – Cryptantha spp.*	Provisional			Y
22.105.03	*Petalonyx thurberi*				Y
22.105.04	*Swallenia alexandrae*		G1	S1	Y
22.105.05	*Wislizenia refracta*	Provisional			Y
42.095.01	*Panicum urvilleanum*		G3	S1	Y
Distichlis spicata					**Alliance**
41.200.00	**Salt grass flats**		**GNR**	**S4**	
41.200.01	*Distichlis spicata / Allenrolfea occidentalis*				Y
41.200.02	*Distichlis spicata – Juncus cooperi*				Y
41.200.03	*Distichlis spicata / Sarcobatus vermiculatus*				Y
41.200.04	*Distichlis spicata / Ericameria albida*				Y
41.200.06	*Distichlis spicata – Jaumea carnosa*				Y
41.200.07	*Distichlis spicata – Frankenia salina – Jaumea carnosa*		G3	S2.2	Y
41.200.11	*Distichlis spicata – Ambrosia chamissonis*		G3	S2	Y
41.200.20	*Distichlis spicata – Sarcocornia pacifica*				Y
41.200.21	*Distichlis spicata (– Baccharis douglasii – Equisetum hymenale)*				Y
41.200.22	*Juncus acutus*	Provisional			Y
41.200.23	*Distichlis spicata – (Scirpus nevadensis)*		G4		Y
45.563.01	*Juncus cooperi*	Provisional	G4	S2	Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Dudleya cymosa – Dudleya lanceolata – Lichen/Moss					**Alliance**
42.630.00	**Live-forever – lichen/moss sparse herbaceous rock outcrop**		**G4**	**S4**	
42.630.01	*Dudleya (blochmaniae ssp. insularis, gnoma) – Sparse Herb*	Provisional	G1	S1	Y
Dudleya greenei – Dudleya spp. Succulent Scrub					**Alliance**
43.120.00	**Greene's live-forever – live-forever species succulent scrub**		**G1**	**S1**	
43.120.01	*Dudleya greenei*	Provisional	G1	S1	Y
Dulichium arundinaceum		**Provisional**			**Alliance**
52.115.00	**Three-way sedge meadows**		**G3?**	**S1**	
52.115.01	*Dulichium arundinaceum*	Provisional			Y
Eleocharis (palustris, rostellata) Alkaline-Saline					**Alliance**
45.260.00	**Common spikerush and beaked spikerush marshes**		**GNR**	**S2S3**	
45.260.01	*Eleocharis rostellata – Muhlenbergia asperifolia*				Y
45.260.03	*Eleocharis rostellata*		G3	S3	Y
Eleocharis acicularis					**Alliance**
45.231.00	**Needle spike rush stands**		**G2**	**S2**	
45.231.01	*Eleocharis acicularis – Eryngium castrense*				Y
45.231.02	*Plagiobothrys mollis – (Eleocharis acicularis – Eryngium mathiasiae)*				Y
45.231.03	*Navarretia spp. – (Eleocharis acicularis – Eryngium alismifolium)*				Y
Eleocharis macrostachya					**Alliance**
45.230.00	**Pale spike rush marshes**		**G4**	**S4**	
45.230.02	*Eleocharis macrostachya – Callitriche hermaphroditica*	Provisional			Y
45.230.03	*Eleocharis macrostachya – Sagittaria montevidensis ssp. calycina*	Provisional			Y
45.230.04	*Eleocharis macrostachya – Eryngium aristulatum var. parishii*				Y
45.230.05	*Eleocharis macrostachya – Lasthenia glaberrima*				Y
45.230.06	*Eleocharis macrostachya – Marsilea vestita*	Provisional			Y
45.230.07	*Eleocharis macrostachya – (Pleuropogon californicus)*	Provisional			Y
Eleocharis quinqueflora					**Alliance**
45.220.00	**Few-flowered spike rush marshes**		**G4**	**S4**	
45.220.02	*Eleocharis quinqueflora – Mimulus primuloides*				Y
45.220.03	*Eleocharis quinqueflora / Aulacomnium palustre*				Y
45.220.04	*Eleocharis quinqueflora / Campylium stellatum*				Y
45.220.05	*Eleocharis quinqueflora / Drepanocladus aduncus – Drepanocladus sordidus*				Y
45.220.06	*Eleocharis quinqueflora / Philonotis fontana*				Y
Elymus glaucus Montane					**Alliance**
41.640.00	**Blue wild rye montane meadows**		**G3?**	**S3?**	
41.640.02	*Elymus glaucus – Carex pellita*				Y
41.640.03	*Elymus glaucus – Carex feta*		G2?		Y
41.640.04	*Elymus glaucus – Heracleum maximum*				Y
Equisetum (arvense, variegatum, hyemale)					**Alliance**
52.070.00	**Field horsetail – scouringrush horsetail – variegated scouringrush wet m**		**GNR**	**S3S4**	
52.070.01	*Equisetum hyemale*	Provisional			N

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Ericameria discoidea – Hulsea algida					**Alliance**
38.120.00	**Fell-fields with California heath-goldenrod and Pacific alpine gold**		**G3?**	**S3?**	
38.120.01	*Ericameria discoidea – Minuartia nuttallii*				Y
38.120.02	*Ericameria discoidea – Linanthus pungens*				Y
38.120.03	*Ericameria discoidea – Phacelia hastata*				Y
38.120.04	*Hulsea algida*				Y
38.120.05	*Hulsea algida – Ericameria discoidea – Phacelia hastata*				Y
38.120.06	*Hulsea algida – Muhlenbergia richardsonis – Achnatherum pinetorum*				Y
Eryngium aristulatum					**Alliance**
42.004.00	**California button-celery patches**		**G2**	**S2**	
42.004.01	*Eryngium aristulatum – Lupinus bicolor*				Y
42.004.02	*Hemizonia congesta*				Y
Eschscholzia (californica) – Lupinus (nanus)					**Alliance**
43.200.00	**California poppy – lupine fields**		**G4**	**S4**	
43.200.02	*Lupinus bicolor*	Provisional	G3	S3	Y
43.200.03	*Salvia carduacea*	Provisional	G3	S3	Y
Festuca brachyphylla					**Alliance**
91.170.00	**Alpine fescue fell-fields**		**G4?**	**S3?**	
91.170.01	*Festuca brachyphylla – Eriogonum ovalifolium*				Y
91.170.02	*Festuca brachyphylla – Penstemon davidsonii*				Y
Festuca idahoensis					**Alliance**
41.250.00	**Idaho fescue grassland**		**G4**	**S3?**	
41.250.01	*Festuca idahoensis – Bromus carinatus*		G3	S3?	Y
41.250.02	*Festuca idahoensis – Festuca rubra*		G3	S3?	Y
41.250.03	*Festuca idahoensis – Achillea millefolium*				Y
41.250.04	*Festuca idahoensis Ultramafic*	Provisional			Y
41.250.05	*Festuca idahoensis – Danthonia californica*	Provisional			Y
41.250.06	*Festuca californica*	Provisional			Y
Festuca rubra					**Alliance**
41.255.00	**Red fescue grassland**		**G4**	**S3?**	
41.255.01	*Festuca rubra*				Y
Frankenia salina					**Alliance**
52.500.00	**Alkali heath marsh**		**G4**	**S3**	
52.500.01	*Frankenia salina – Limonium californicum – Monanthochloe littoralis – Sarcocornia pacifica*		G3	S2?	Y
52.500.02	*Frankenia salina*				Y
52.500.03	*Frankenia salina / Agrostis avenacea*				Y
52.500.04	*Frankenia salina – Distichlis spicata*				Y
52.500.05	*Lasthenia ferrisiae – Lasthenia conjugens*				Y
52.500.06	*Suaeda taxifolia – Hordeum murinum*				Y
52.500.07	*Frankenia salina – Atriplex californica*	Provisional			Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Glyceria (elata, striata)					**Alliance**
41.222.00	**Manna grass meadows**		**G4**	**S3?**	
41.222.01	*Glyceria elata*				Y
41.222.02	*Glyceria elata – Scirpus microcarpus*				Y
41.222.03	*Glyceria elata – Lotus oblongifolius*				Y
41.222.04	*Glyceria striata*		G3		Y
Glyceria ×occidentalis		**Provisional**			**Alliance**
41.223.00	**Northwest manna grass marshes**		**G3?**	**S3?**	
Grindelia (camporum, stricta)		**Provisional**			**Alliance**
52.206.00	**Gum plant patches**		**G2G3**	**S2S3**	
52.206.01	*Grindelia camporum*				Y
52.206.02	*Grindelia stricta*	Provisional			Y
Heterotheca (oregona, sessiliflora)					**Alliance**
42.230.00	**Goldenaster patches**		**G3**	**S3**	
42.230.01	*Heterotheca oregona*		G3	S3	Y
42.230.02	*Heterotheca sessiliflora*	Provisional	G3	S3	Y
Hordeum brachyantherum					**Alliance**
42.052.00	**Meadow barley patches**		**G2**	**S2**	
42.052.01	*Hordeum brachyantherum*		G2		Y
42.052.02	*Hordeum brachyantherum – Polypogon monspeliensis*				Y
42.052.03	*Hordeum brachyantherum – Senecio triangularis*				Y
42.052.04	*Hordeum brachyantherum – Poa pratensis*				Y
Hydrocotyle (ranunculoides, umbellata)					**Alliance**
52.117.00	**Mats of floating pennywort**		**G4**	**S3?**	
52.117.01	*Hydrocotyle ranunculoides*				Y
52.117.02	*Hydrocotyle ranunculoides – Schoenoplectus pungens*	Provisional			Y
Isoetes (bolanderi, echinospora, howellii, nuttallii, occidentalis)		**Provisional**			**Alliance**
52.109.00	**Quillwort beds**		**G3**	**S3?**	
Juncus (oxymeris, xiphioides)		**Provisional**			**Alliance**
45.568.00	**Iris-leaf rush seeps**		**G2?**	**S2?**	
45.568.01	*Juncus xiphioides*	Provisional			Y
45.568.02	*Juncus oxymeris*	Provisional			Y
Juncus lescurii					**Alliance**
45.569.00	**Salt rush swales**		**G3**	**S2?**	
45.569.01	*Juncus lescurii*				Y
45.569.02	*Juncus (lescurii) – Distichlis spicata*				Y
Juncus nevadensis					**Alliance**
45.567.00	**Sierra rush marshes**		**G3?**	**S3?**	
45.567.01	*Juncus nevadensis*				Y
45.567.02	*Juncus nevadensis – Carex leporinella*				Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
45.567.03	*Juncus nevadensis – Eleocharis quinqueflora*				Y
Juncus parryi					**Alliance**
45.566.00	**Parry's rush outcrops**		**G4**	**S4**	
45.566.01	*Juncus parryi – Eriogonum incanum*		G3?		Y
Kobresia myosuroides					**Alliance**
91.115.00	**Pacific bog sedge meadows**		**G5**	**S1**	
91.115.01	*Kobresia myosuroides – Thalictrum alpinum*				Y
Lasthenia californica – Plantago erecta – Vulpia microstachys					**Alliance**
44.108.00	**California goldfields – dwarf plantain – small fescue flower fields**		**G4**	**S4**	
44.108.01	*Lasthenia californica – Plantago erecta – Hesperevax sparsiflora*				Y
44.108.03	*Vulpia microstachys – Plantago erecta – Calycadenia (truncata, multiglandulosa)*		G2	S2?	Y
44.108.04	*Vulpia microstachys – Plantago erecta*				Y
44.108.07	*Vulpia microstachys – Selaginella hansenii – Lupinus spectabilis*				Y
44.108.08	*Vulpia microstachys – Elymus elymoides – Achnatherum lemmonii*				Y
44.108.09	*Vulpia microstachys – Navarretia tagetina*				Y
44.108.10	*Vulpia microstachys – Selaginella hansenii*				Y
44.108.11	*Vulpia microstachys – Selaginella hansenii – Lupinus nanus*				Y
44.108.12	*Lasthenia (californica, gracilis)*				Y
44.108.13	*Lasthenia californica – Plagiobothrys acanthocarpa – Medicago polymorpha*				Y
44.108.14	*Lasthenia gracilis – Plantago erecta – Plagiobothrys canescens*				Y
44.108.15	*Lasthenia minor*	Provisional			Y
44.108.16	*Layia pentachaeta – Plagiobothrys (canescens)*	Provisional			Y
44.108.17	*Lepidium nitidum – Trifolium gracilentum – Vulpia microstachys*				Y
44.108.18	*Vulpia microstachys*				Y
44.108.20	*Lotus humistratus – Plantago erecta – Lomatium spp.*	Provisional			Y
44.108.21	*Micropus californicus*	Provisional			Y
44.108.22	*Erigeron glaucus – Lasthenia californica*				Y
44.108.23	*Pectocarya (linearis, penicillata)*	Provisional			Y
44.108.25	*Layia platyglossa*	Provisional			Y
44.109.01	*Lasthenia californica – Atriplex coronata var. notatior*	Provisional			Y
44.109.04	*Lasthenia californica – Lupinus bicolor – Layia platyglossa – Bromus spp.*				Y
44.109.05	*Vulpia microstachys – Lasthenia californica – Agrostis elliottiana*				Y
44.109.07	*Lasthenia californica – Atriplex californica*	Provisional			Y
Lasthenia fremontii – Distichlis spicata					**Alliance**
44.119.00	**Fremont's goldfields – salt grass alkaline vernal pools**		**G2**	**S2**	
44.119.01	*Downingia bella – Lilaea scilloides*				Y
44.119.02	*Downingia cuspidata – Myosurus minimus*				Y
44.119.03	*Downingia insignis – Psilocarphus brevissimus*				Y
44.119.04	*Downingia pulchella – Cressa truxillensis*				Y
44.119.05	*Downingia pulchella – Distichlis spicata*				Y
44.119.06	*Hordeum (depressum, murinum ssp. leporinum)*				Y
44.119.07	*Lasthenia fremontii – Pleuropogon californicus*				Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
44.119.08	*Lasthenia glaberrima – Atriplex persistens*				Y
44.119.09	*Lasthenia platycarpha – Lepidium latipes*				Y
44.119.10	*Limnanthes douglasii ssp. rosea – Pleuropogon californicus*				Y
44.119.11	*Lasthenia fremontii – Distichlis spicata*	Provisional			Y
44.119.12	*Frankenia salina – Psilocarphus brevissimus*	Provisional			Y
44.119.13	*Atriplex vallicola – Lasthenia ferrisiae – Lepidium jaredii*				Y
44.119.14	*Spergularia macrotheca – Hordeum (murinum)*				Y
Lasthenia fremontii – Downingia (bicornuta)					**Alliance**
42.007.00	**Fremont's goldfields – Downingia vernal pools**		**G2**	**S2**	
42.007.01	*Downingia bicornuta*				Y
42.007.02	*Downingia (bicornuta, cuspidata)*				Y
42.007.03	*Lasthenia fremontii – Downingia bicornuta*				Y
42.007.04	*Lasthenia fremontii – Downingia ornatissima*				Y
42.007.05	*Ranunculus bonariensis – Holocarpha virgata*				Y
42.007.06	*Eryngium (vaseyi, castrense)*				Y
42.007.07	*Lasthenia fremontii*	Provisional			Y
42.007.08	*Lasthenia californica – Downingia bicornuta*				Y
Lasthenia glaberrima					**Alliance**
44.140.00	**Smooth goldfields vernal pool bottoms**		**G2**	**S2**	
44.140.01	*Lasthenia glaberrima – Downingia bicornuta*				Y
44.140.02	*Lasthenia glaberrima – Pleuropogon californicus*				Y
44.140.03	*Lasthenia glaberrima – Pogogyne douglasii*				Y
44.140.04	*Lasthenia glaberrima – Trifolium variegatum*				Y
44.140.05	*Lasthenia glaberrima – Downingia insignis*				Y
44.140.06	*Lasthenia glaberrima – Lupinus bicolor*				Y
Layia fremontii – Achyrachaena mollis					**Alliance**
42.002.00	**Fremont's tidy-tips – blow wives vernal pools**		**G3**	**S3?**	
41.321.12	*Zigadenus fremontii – Lolium perenne*	Provisional			Y
42.002.01	*Layia fremontii – Achyrachaena mollis*				Y
42.002.02	*Layia fremontii – Lasthenia californica – Achyrachaena mollis*				Y
42.002.03	*Layia fremontii – Leontodon saxatilis – Plagiobothrys greenei*				Y
42.002.04	*Plagiobothrys austiniae – Achyrachaena mollis*				Y
Leymus cinereus – Leymus triticoides					**Alliance**
41.081.00	**Ashy ryegrass – creeping ryegrass turfs**		**G3**	**S3**	
41.020.01	*Leymus cinereus*	Provisional	G2G3	S2?	Y
41.080.01	*Leymus triticoides*				Y
41.080.02	*Leymus triticoides – Bromus spp. – Avena spp.*				Y
41.080.03	*Leymus triticoides – Lolium perenne*				Y
41.080.04	*Leymus triticoides – Carduus pycnocephalus – Geranium dissectum*				Y
41.080.05	*Leymus triticoides – Anemopsis californica*				Y
41.080.06	*Leymus triticoides – Poa secunda*				Y
41.081.01	*Leymus triticoides – Sporobolus airoides*	Provisional			Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Leymus condensatus					**Alliance**
41.265.00	**Giant wild rye grassland**		**G3**	**S3**	
41.265.01	*Leymus condensatus*		G3	S3	Y
Leymus mollis					**Alliance**
41.260.00	**Sea lyme grass patches**		**G4**	**S2**	
41.260.01	*Leymus mollis – Carpobrotus edulis*				Y
41.260.02	*Leymus mollis – Ammophila arenaria*				Y
41.260.03	*Leymus mollis – Abronia latifolia – (Cakile sp.)*				Y
Mimulus (guttatus)					**Alliance**
44.111.00	**Common monkey flower seeps**		**G4?**	**S3?**	
44.111.01	*Mimulus guttatus*				Y
44.111.02	*Mimulus guttatus – Vulpia microstachys*				Y
44.111.03	*Mimulus guttatus – (Mimulus spp.)*				Y
44.111.04	*Mimulus lewisii*				Y
Monolopia (lanceolata) – Coreopsis (calliopsidea)					**Alliance**
36.130.00	**Monolopia – leafy-stemmed tickseed fields**		**G3**	**S3**	
36.130.01	*Monolopia lanceolata*		G3	S3	Y
36.130.02	*Coreopsis calliopsidea – Mentzelia pectinata*		G3	S3	Y
36.130.03	*Monolopia stricta*	Provisional	G2	S2	Y
36.130.04	*Coreopsis bigelovii – Layia glandulosa – Mentzelia spp. / Ephedra nevadensis*	Provisional			Y
Montia fontana – Sidalcea calycosa					**Alliance**
44.113.00	**Water blinks – annual checkerbloom vernal pools**		**G2**	**S2**	
44.113.01	*Montia fontana – Sidalcea calycosa*				Y
Muhlenbergia filiformis		**Provisional**			**Alliance**
41.276.00	**Pullup muhly meadows**		**G4?**	**S4?**	
41.276.01	*Muhlenbergia filiformis*	Provisional			Y
41.276.02	*Muhlenbergia filiformis – Agrostis exarata*	Provisional			Y
41.276.03	*Muhlenbergia filiformis – Artemisia ludoviciana*	Provisional			Y
41.276.04	*Muhlenbergia filiformis – Penstemon rydbergii*	Provisional			Y
Muhlenbergia rigens					**Alliance**
41.278.00	**Deer grass beds**		**G3**	**S2?**	
41.278.01	*Muhlenbergia rigens*				Y
Nassella spp. – Melica spp.					**Alliance**
41.151.00	**Needle grass - melic grass grassland**		**G4**	**S4**	
41.110.01	*Nassella lepida*	Provisional	G3	S3	Y
41.140.01	*Nassella cernua*				Y
41.150.01	*Nassella pulchra – Lolium perenne – (Trifolium spp.)*		G3	S3?	Y
41.150.03	*Nassella pulchra – Sanicula bipinnatifida*				Y
41.150.04	*Nassella pulchra*				Y
41.150.05	*Nassella pulchra – Avena spp. – Bromus spp.*		G3	S3?	Y
41.150.06	*Nassella pulchra – Erodium spp. – Avena barbata*				Y
41.150.07	*Nassella pulchra / Hazardia squarrosa*		G3	S3	Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
41.150.09	*Nassella pulchra – Melica californica – annual grass*		G3	S3	Y
41.150.10	*Nassella pulchra – Distichlis spicata – Bromus spp.*				Y
41.150.11	*Nassella pulchra – Leontodon saxatilis*				Y
41.150.12	*Nassella pulchra – Lolium perenne – Astragalus gambelianus – Lepidium nitidum*				Y
41.150.13	*Nassella pulchra – Lolium perenne – Calystegia collina*				Y
41.150.14	*Nassella pulchra / Baccharis pilularis*		G2	S2.2?	Y
41.151.01	*Melica californica*	Provisional			Y
41.151.02	*Nassella pulchra – Achnatherum lemmonii*	Provisional			Y
41.151.03	*Nassella pulchra – Hemizonia congesta*	Provisional			Y
41.151.04	*Nassella pulchra – Lolium perenne – Plantago erecta Serpentine*				Y
41.151.05	*Nassella pulchra – Plantago lanceolata*	Provisional			Y
41.151.06	*Nassella pulchra – Corethrogyne filaginifolia*				Y
41.275.01	*Melica torreyana*	Provisional			Y
Nuphar lutea		**Provisional**			**Alliance**
52.110.00	**Yellow pond-lily mats**		**G5**	**S3?**	
Oenanthe sarmentosa					**Alliance**
52.119.00	**Water-parsley marsh**		**G4**	**S2?**	
52.119.01	*Oenanthe sarmentosa*				Y
Oxypolis occidentalis					**Alliance**
45.418.00	**Western cowbane meadows**		**G3**	**S3**	
45.418.02	*Oxypolis occidentalis – Bistorta bistortoides*				Y
45.418.03	*Oxypolis occidentalis – Carex amplifolia*				Y
45.418.04	*Oxypolis occidentalis – Eleocharis montevidensis*				Y
45.418.05	*Oxypolis occidentalis – Senecio triangularis*				Y
45.418.06	*Oxypolis occidentalis / Philonotis fontana*				Y
Oxyria digyna		**Provisional**			**Alliance**
91.122.00	**Mountain sorrel patches**		**G4**	**S3?**	
91.122.01	*Draba lemmonii – Oxyria digyna*	Provisional			Y
Penstemon heterodoxus		**Provisional**			**Alliance**
45.414.00	**Heretic penstemon patches**		**G4?**	**S3?**	
45.414.01	*Antennaria media – Penstemon heterodoxus*	Provisional			Y
45.414.02	*Penstemon heterodoxus – Achillea millefolium*	Provisional			Y
Phlox covillei					**Alliance**
91.123.00	**Coville's phlox fell-fields**		**G4**	**S3**	
91.120.06	*Ivesia muirii*				Y
91.120.08	*Podistera nevadensis – Arenaria kingii*				Y
91.120.36	*Festuca minutiflora – Penstemon davidsonii*				Y
91.123.01	*Phlox covillei – Elymus elymoides – Podistera nevadensis*		G3?		Y
91.123.02	*Phlox covillei – Elymus elymoides – Podistera nevadensis – Erigeron pygmaeus*				Y
91.123.03	*Astragalus kentrophyta – Draba oligosperma*				Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
91.123.04	*Draba oligosperma – Poa glauca ssp. rupicola*				Y
91.123.05	*Phlox covillei – Eriogonum incanum*				Y
91.123.06	*Podistera nevadensis – Erigeron pygmaeus*				Y
91.123.07	*Phlox (covillei) – Ivesia shockleyi*				Y
91.123.08	*Phlox covillei – Linum lewisii*				Y
91.123.09	*Phlox covillei – Eriogonum gracilipes*				Y
Phlox pulvinata					**Alliance**
91.150.00	**Cushion phlox fell-fields**		**G4**	**S3**	
91.150.02	*Phlox pulvinata – Anelsonia eurycarpa*				Y
91.150.03	*Phlox pulvinata – Ericameria suffruticosa – Ipomopsis congesta*				Y
91.150.04	*Phlox pulvinata – Lupinus argenteus var. montigenus*				Y
91.150.05	*Phlox pulvinata – Festuca brachyphylla*				Y
91.150.06	*Phlox pulvinata – Ivesia gordonii*				Y
Plagiobothrys nothofulvus					**Alliance**
43.300.00	**Popcorn flower fields**		**G4**	**S4**	
43.300.02	*Plagiobothrys nothofulvus – Castilleja exserta – Lupinus nanus*	Provisional			Y
Pleuraphis jamesii					**Alliance**
41.610.00	**James' galleta shrub-steppe**		**G3**	**S2**	
41.610.04	*Pleuraphis jamesii*				Y
41.610.05	*Scleropogon brevifolius – Pleuraphis jamesii – Bouteloua eriopoda*				Y
41.610.06	*Bouteloua eriopoda – Pleuraphis jamesii*				Y
Pleuraphis rigida					**Alliance**
41.030.00	**Big galleta shrub-steppe**		**G3**	**S2**	
41.030.01	*Pleuraphis rigida*				Y
41.030.04	*Pleuraphis rigida – Dalea mollissima*				Y
41.030.05	*Pleuraphis rigida / Atriplex canescens*		G3	S2	Y
41.030.06	*Pleuraphis rigida / Ambrosia dumosa*				Y
41.030.07	*Pleuraphis rigida / Ephedra (californica, trifurca)*				Y
Poa secunda – Muhlenbergia richardsonis – Carex douglasii					**Alliance**
41.279.00	**Onesided bluegrass – mat muhly – Douglas' sedge moist meadow**		**G4?**	**S3**	
41.180.02	*Poa secunda ssp. secunda*				Y
41.180.03	*Poa secunda Moist*				Y
41.180.04	*Poa secunda – Danthonia unispicata*				Y
41.277.01	*Muhlenbergia richardsonis*	Provisional			Y
41.277.02	*Muhlenbergia richardsonis – Achnatherum pinetorum*	Provisional			Y
45.169.01	*Carex douglasii*	Provisional			Y
Polygonum lapathifolium – Xanthium strumarium					**Alliance**
42.207.00	**Smartweed – cocklebur patches**		**G5**	**S5**	
42.207.04	*Bidens frondosa*	Provisional			Y
Pseudoroegneria spicata					**Alliance**
41.040.00	**Bluebunch wheat grass grassland**		**G4**	**S2**	
41.040.01	*Pseudoroegneria spicata – Poa secunda*		G4	S2	Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
Ptilagrostis kingii					**Alliance**
41.225.00	**King's needle grass meadows**		**G4**	**S4**	
41.225.01	*Ptilagrostis kingii*		G3?		Y
Ruppia (cirrhosa, maritima)					**Alliance**
52.202.00	**Ditch-grass or widgeon-grass mats**		**G4?**	**S2**	
52.202.02	*Ruppia cirrhosa – algae*				Y
Sarcocornia pacifica (Salicornia depressa)					**Alliance**
52.215.00	**Pickleweed mats**		**G4**	**S3**	
52.215.01	*Sarcocornia pacifica – Cuscuta salina – Spartina densiflora*				Y
52.215.02	*Sarcocornia pacifica – Distichlis spicata*				Y
52.215.03	*Sarcocornia pacifica – Jaumea carnosa – Distichlis spicata*		G3	S3	Y
52.215.04	*Sarcocornia pacifica Managed*				Y
52.215.05	*Sarcocornia pacifica Tidal*				Y
52.215.06	*Sarcocornia pacifica – Atriplex prostrata*				Y
52.215.07	*Sarcocornia pacifica – Bolboschoenus maritimus*				Y
52.215.09	*Sarcocornia pacifica – Frankenia salina*				Y
52.215.10	*Sarcocornia pacifica – Grindelia stricta*				Y
52.215.11	*Sarcocornia pacifica – Jaumea carnosa*				Y
52.215.12	*Sarcocornia pacifica – Lepidium latifolium*				Y
52.215.13	*Sarcocornia pacifica – Spartina foliosa*				Y
52.215.14	*Sarcocornia pacifica / algae*		G4		Y
52.215.15	*Sarcocornia pacifica – Brassica nigra*		G4		Y
52.215.16	*Sarcocornia pacifica – Cotula coronopifolia*				Y
52.215.17	*Sarcocornia pacifica – Crypsis schoenoides*				Y
52.215.18	*Sarcocornia pacifica – Echinochloa crus-galli – Polygonum – Xanthium strumarium*				Y
52.215.19	*Sarcocornia pacifica / annual grasses (Polypogon, Hordeum, Lolium)*				Y
52.215.20	*Sarcocornia pacifica – Sesuvium verrucosum*				Y
52.215.21	*Sarcocornia pacifica – Frankenia salina – Suaeda taxifolia*		G2	S2?	Y
52.215.22	*Sarcocornia pacifica – Jaumea carnosa – Batis maritima*				Y
52.215.23	*Salicornia bigelovii*	Provisional			Y
Saxifraga nidifica		**Provisional**			**Alliance**
91.124.00	**Pink saxifrage patches**		**G4?**	**S3?**	
91.124.02	*Rhodiola integrifolia – Selaginella watsonii*	Provisional			Y
91.124.03	*Polygonum minimum*	Provisional			Y
91.124.04	*Saxifraga bryophora*	Provisional			Y
91.124.05	*Saxifraga nidifica – Mimulus rubellus*	Provisional			Y
Saxifraga tolmiei		**Provisional**			**Alliance**
91.125.00	**Patches of Tolmie's alpine saxifrage**		**G4**	**S3?**	
91.125.01	*Saxifraga tolmiei – Luzula divaricata*	Provisional			Y
Schoenoplectus (acutus, californicus)					**Alliance**
52.128.00	**Hardstem and California bulrush marshes**		**GNR**	**S3S4**	
52.102.02	*Schoenoplectus acutus – Typha domingensis*				Y

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
52.114.01	*Schoenoplectus californicus – Schoenoplectus acutus*		G5		Y
52.114.02	*Schoenoplectus californicus*				Y
52.114.05	*Schoenoplectus californicus – Typha latifolia*				Y
52.114.06	*Schoenoplectus californicus – Schoenoplectus acutus / Rosa californica*				Y
52.122.01	*Schoenoplectus acutus*				Y
52.122.03	*Schoenoplectus acutus – Typha angustifolia*				Y
52.122.04	*Schoenoplectus acutus – Typha latifolia*				Y
52.122.05	*Schoenoplectus acutus – Phragmites australis*				N
52.122.06	*Schoenoplectus acutus – Xanthium strumarium*				Y
52.128.01	*Schoenoplectus (acutus, californicus) – Wetland herbs*	Provisional			Y
Schoenoplectus americanus					**Alliance**
52.111.00	**American bulrush marsh**		**G5**	**S3**	
52.111.02	*Schoenoplectus americanus / Argentina egedii*				Y
52.111.03	*Schoenoplectus americanus / Lepidium latifolium*				Y
52.111.04	*Schoenoplectus americanus*				Y
52.111.06	*Schoenoplectus americanus – Schoenoplectus californicus – Schoenoplectus acutus*	Provisional			Y
Scirpus microcarpus					**Alliance**
52.113.00	**Small-fruited bulrush marsh**		**G4**	**S2**	
52.113.01	*Scirpus microcarpus*		G4		Y
52.113.02	*Scirpus microcarpus – Oxypolis occidentalis*				Y
52.113.03	*Scirpus microcarpus – Scirpus congdonii*				Y
Selaginella bigelovii					**Alliance**
42.062.00	**Bushy spikemoss mats**		**G4**	**S3**	
42.062.01	*Selaginella bigelovii / Eriogonum fasciculatum*		G4	S3	Y
Sesuvium verrucosum					**Alliance**
52.210.00	**Western sea-purslane marshes**		**G3?**	**S2**	
52.210.01	*Sesuvium verrucosum*				Y
52.210.02	*Sesuvium verrucosum – Cotula coronopifolia*				Y
52.210.03	*Sesuvium verrucosum – Distichlis spicata*				Y
52.210.04	*Sesuvium verrucosum – Lolium perenne*				Y
Sparganium (angustifolium)					**Alliance**
52.010.00	**Mats of bur-reed leaves**		**G4**	**S3?**	
52.010.01	*Sparganium angustifolium*				Y
Spartina foliosa					**Alliance**
52.020.00	**California cordgrass marsh**		**G3**	**S3**	
52.020.01	*Spartina foliosa – Sarcocornia pacifica*				Y
52.020.02	*Spartina foliosa*				Y
Spergularia marina		**Provisional**			**Alliance**
52.213.00	**Saltmarsh sand-spurrey**		**G3?**	**S3?**	
Sporobolus airoides – Muhlenbergia asperifolia – Spartina gracilis					**Alliance**
52.060.00	**Alkali sacaton – scratchgrass – alkali cordgrass alkaline wet meadow**		**G4**	**S2**	

Primary Life form: Herb

CaCode	Name		Rarity		Sensitive
41.010.01	*Sporobolus airoides*		GNR	S2	Y
41.010.02	*Sporobolus airoides / Ericameria nauseosa*				Y
41.010.03	*Sporobolus airoides / Allenrolfea occidentalis*				Y
52.030.01	*Spartina gracilis*		GNR	S1	Y
52.060.01	*Muhlenbergia asperifolia*	Provisional			Y
52.060.02	*Puccinellia nuttalliana*		G3?		Y
52.060.03	*Sporobolus airoides – Distichlis spicata*		G4?	S3	Y
52.060.04	*Ivesia kingii – Spartina gracilis*	Provisional		S2	Y
Stuckenia (pectinata) – Potamogeton spp.					**Alliance**
52.107.00	**Pondweed mats**		**G3G5**	**S3?**	
52.107.01	*Stuckenia pectinata*				Y
52.107.02	*Potamogeton spp.*				Y
Torreyochloa pallida					**Alliance**
45.171.00	**Floating mats of weak manna grass**		**G3**	**S3?**	
45.171.01	*Torreyochloa pallida var. pauciflora*				Y
45.171.02	*Torreyochloa pallida var. pauciflora – Isoetes bolanderi*				Y
Triantha occidentalis – Narthecium californicum					**Alliance**
45.135.00	**Western false asphodel – California bog asphodel fens**		**G2?**	**S2?**	
45.135.01	*Triantha occidentalis – Rhynchospora alba*				Y
45.135.02	*Triantha occidentalis / Sphagnum teres*				Y
45.135.03	*Triantha occidentalis – Narthecium californicum*				Y
Trifolium longipes		**Provisional**			**Alliance**
45.426.00	**Long-stalk clover meadows**		**G3?**	**S3?**	
Trifolium variegatum					**Alliance**
42.005.00	**White-tip clover swales**		**G3?**	**S3?**	
42.005.01	*Trifolium variegatum*				Y
42.005.02	*Trifolium gracilentum – Hesperevax caulescens*				Y
42.005.03	*Trifolium variegatum – Lolium perenne – Leontodon saxatilis*				Y
42.005.05	*(Trifolium variegatum – Vulpia bromoides) – Hypochaeris glabra – Leontodon taraxacoides*				Y
42.005.06	*Trifolium variegatum – Juncus bufonius*				Y
Typha (angustifolia, domingensis, latifolia)					**Alliance**
52.050.00	**Cattail marshes**		**G5**	**S5**	
41.061.03	*Phragmites australis ssp. americanus*	Provisional			Y
Veratrum californicum					**Alliance**
45.423.00	**White corn lily patches**		**G5**	**S4**	
45.423.01	*Veratrum californicum – Senecio triangularis*		G4	S3	Y

ATTACHMENT B

Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF FISH AND WILDLIFE

DATE: March 20, 2018

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1. INTRODUCTION AND PURPOSE

The conservation of special status native plants and their habitats, as well as sensitive natural communities, is integral to maintaining biological diversity. The purpose of these protocols is to facilitate a consistent and systematic approach to botanical field surveys and assessments of special status plants and sensitive natural communities so that reliable information is produced and the potential for locating special status plants and sensitive natural communities is maximized. These protocols may also help those who prepare and review environmental documents determine when botanical field surveys are needed, how botanical field surveys may be conducted, what information to include in a botanical survey report, and what qualifications to consider for botanical field surveyors. These protocols are meant to help people meet California Environmental Quality Act (CEQA)[1] requirements for adequate disclosure of potential impacts to plants and sensitive natural communities. These protocols may be used in conjunction with protocols formulated by other agencies, for example, those developed by the U.S. Army Corps of Engineers to delineate jurisdictional wetlands[2] or by the U.S. Fish and Wildlife Service to survey for the presence of special status plants[3].

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1 Available at: http://resources.ca.gov/ceqa

2 Available at: http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/techbio.aspx

3 U.S. Fish and Wildlife Service Survey Guidelines: https://www.fws.gov/sacramento/es/Survey-Protocols-Guidelines/

Department of Fish and Wildlife Trustee and Responsible Agency Mission

The mission of the California Department of Fish and Wildlife (CDFW) is to manage California's diverse wildlife and native plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. CDFW has jurisdiction over the conservation, protection, and management of wildlife, native plants, and habitat necessary to maintain biologically sustainable populations (Fish & G. Code, § 1802). CDFW, as trustee agency under CEQA Guidelines section 15386, provides expertise in reviewing and commenting on environmental documents and provides protocols regarding potential negative impacts to those resources held in trust for the people of California.

Certain species are in danger of extinction because their habitats have been severely reduced in acreage, are threatened with destruction or adverse modification, or because of a combination of these and other factors. The California Endangered Species Act (CESA) and Native Plant Protection Act (NPPA) provide additional protections for such species, including take prohibitions (Fish & G. Code, § 2050 *et seq.*; Fish & G. Code, § 1908). As a responsible agency, CDFW has the authority to issue permits for the take of species listed under CESA and NPPA if the take is incidental to an otherwise lawful activity; CDFW has determined that the impacts of the take have been minimized and fully mitigated; and the take would not jeopardize the continued existence of the species (Fish & G. Code, § 2081, subd. (b); Cal. Code Regs., tit. 14 § 786.9, subd. (b)). Botanical field surveys are one of the preliminary steps to detect special status plant species and sensitive natural communities that may be impacted by a project.

Definitions

Botanical field surveys provide information used to determine the potential environmental effects of proposed projects on special status plants and sensitive natural communities as required by law (e.g., CEQA, CESA, and federal Endangered Species Act (ESA)).

Special status plants, for the purposes of this document, include all plants that meet one or more of the following criteria:

- Listed or proposed for listing as threatened or endangered under the ESA or candidates for possible future listing as threatened or endangered under the ESA (50 C.F.R., § 17.12).
- Listed or candidates for listing by the State of California as threatened or endangered under CESA (Fish & G. Code, § 2050 et seq.)[4]. In CESA, “endangered species” means a native species or subspecies of plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease (Fish & G. Code, § 2062). “Threatened species” means a native species or subspecies of plant that,

[4] Refer to current online published lists available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109390&inline

although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by CESA (Fish & G. Code, § 2067). "Candidate species" means a native species or subspecies of plant that the California Fish and Game Commission has formally noticed as being under review by CDFW for addition to either the list of endangered species or the list of threatened species, or a species for which the California Fish and Game Commission has published a notice of proposed regulation to add the species to either list (Fish & G. Code, § 2068).

- Listed as rare under the California Native Plant Protection Act (Fish & G. Code, § 1900 et seq.). A plant is rare when, although not presently threatened with extinction, the species, subspecies, or variety is found in such small numbers throughout its range that it may be endangered if its environment worsens (Fish & G. Code, § 1901).
- Meet the definition of rare or endangered under CEQA Guidelines section 15380, subdivisions (b) and (d), including:
    - Plants considered by CDFW to be "rare, threatened or endangered in California." This includes plants tracked by the California Natural Diversity Database (CNDDB) and the California Native Plant Society (CNPS) as California Rare Plant Rank (CRPR) 1 or 2[5];
    - Plants that may warrant consideration on the basis of declining trends, recent taxonomic information, or other factors. This may include plants tracked by the CNDDB and CNPS as CRPR 3 or 4[6].
- Considered locally significant plants, that is, plants that are not rare from a statewide perspective but are rare or uncommon in a local context such as within a county or region (CEQA Guidelines, § 15125, subd. (c)), or as designated in local or regional plans, policies, or ordinances (CEQA Guidelines, Appendix G). Examples include plants that are at the outer limits of their known geographic range or plants occurring on an atypical soil type.

Sensitive natural communities are communities that are of limited distribution statewide or within a county or region and are often vulnerable to environmental effects of projects. These communities may or may not contain special status plants or their

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5 See CNDDB's Special Vascular Plants, Bryophytes, and Lichens List for plant taxa with a CRPR of 1 or 2: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109383&inline

6 CRPR 3 plants (plants about which more information is needed) and CRPR 4 plants (plants of limited distribution) may warrant consideration under CEQA Guidelines section 15380. Impacts to CRPR 3 plants may warrant consideration under CEQA if sufficient information is available to assess potential impacts to such plants. Impacts to CRPR 4 plants may warrant consideration under CEQA if cumulative impacts to such plants are significant enough to affect their overall rarity. Data on CRPR 3 and 4 plants should be submitted to CNDDB. Such data aids in determining and revising the CRPR of plants. See CNDDB's Special Vascular Plants, Bryophytes, and Lichens List for plant taxa with a CRPR of 3 or 4: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109383&inline

habitat. CDFW's *List of California Terrestrial Natural Communities*[7] is based on the best available information, and indicates which natural communities are considered sensitive at the current stage of the California vegetation classification effort. See the Vegetation Classification and Mapping Program (VegCAMP) website for additional information on natural communities and vegetation classification[8].

2. BOTANICAL FIELD SURVEYS

Evaluate the need for botanical field surveys prior to the commencement of any activities that may modify vegetation, such as clearing, mowing, or ground-breaking activities. It is appropriate to conduct a botanical field survey when:

- Natural (or naturalized) vegetation occurs in an area that may be directly or indirectly affected by a project (project area), and it is unknown whether or not special status plants or sensitive natural communities occur in the project area;
- Special status plants or sensitive natural communities have historically been identified in a project area; or
- Special status plants or sensitive natural communities occur in areas with similar physical and biological properties as a project area.

Survey Objectives

Conduct botanical field surveys in a manner which maximizes the likelihood of locating special status plants and sensitive natural communities that may be present. Botanical field surveys should be floristic in nature, meaning that every plant taxon that occurs in the project area is identified to the taxonomic level necessary to determine rarity and listing status. "Focused surveys" that are limited to habitats known to support special status plants or that are restricted to lists of likely potential special status plants are not considered floristic in nature and are not adequate to identify all plants in a project area to the level necessary to determine if they are special status plants.

For each botanical field survey conducted, include a list of all plants and natural communities detected in the project area. More than one field visit is usually necessary to adequately capture the floristic diversity of a project area. An indication of the prevalence (estimated total numbers, percent cover, density, etc.) of the special status plants and sensitive natural communities in the project area is also useful to assess the significance of a particular plant population or natural community.

Survey Preparation

Before botanical field surveys are conducted, the botanical field surveyors should compile relevant botanical information in the general project area to provide a regional

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7 Available at: https://www.wildlife.ca.gov/Data/VegCAMP/Natural-Communities#natural%20communities%20lists

8 Available at: https://www.wildlife.ca.gov/Data/VegCAMP

context. Consult the CNDDB[9] and BIOS[10] for known occurrences of special status plants and sensitive natural communities in the project area prior to botanical field surveys. Generally, identify vegetation and habitat types potentially occurring in the project area based on biological and physical properties (e.g. soils) of the project area and surrounding ecoregion[11]. Then, develop a list of special status plants and sensitive natural communities with the potential to occur within the vegetation and habitat types identified. The list of special status plants with the potential to occur in the project area can be created with the help of the CNDDB QuickView Tool[12] which allows the user to generate lists of CNDDB-tracked elements that occur within a particular U.S. Geological Survey 7.5' topographic quad, surrounding quads, and counties within California. Resulting lists should only be used as a tool to facilitate the use of reference sites, with the understanding that special status plants and sensitive natural communities in a project area may not be limited to those on the list. Botanical field surveys and subsequent reporting should be comprehensive and floristic in nature and not restricted to or focused only on a list. Include in the botanical survey report the list of potential special status plants and sensitive natural communities that was created, and the list of references used to compile the background botanical information for the project area.

Survey Extent

Botanical field surveys should be comprehensive over the entire project area, including areas that will be directly or indirectly impacted by the project. Adjoining properties should also be surveyed where direct or indirect project effects could occur, such as those from fuel modification, herbicide application, invasive species, and altered hydrology. Surveys restricted to known locations of special status plants may not identify all special status plants and sensitive natural communities present, and therefore do not provide a sufficient level of information to determine potential impacts.

Field Survey Method

Conduct botanical field surveys using systematic field techniques in all habitats of the project area to ensure thorough coverage. The level of effort required per given area and habitat is dependent upon the vegetation and its overall diversity and structural complexity, which determines the distance at which plants can be identified. Conduct botanical field surveys by traversing the entire project area to ensure thorough coverage, documenting all plant taxa observed. Parallel survey transects may be necessary to ensure thorough survey coverage in some habitats. The level of effort should be sufficient to provide comprehensive reporting. Additional time should be allocated for plant identification in the field.

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9 Available at: https://www.wildlife.ca.gov/Data/CNDDB

10 Available at: https://www.wildlife.ca.gov/Data/BIOS

11 Ecological Subregions of the United States, available at: http://www.fs.fed.us/land/pubs/ecoregions/toc.html

12 Available at: https://www.wildlife.ca.gov/Data/CNDDB/Maps-and-Data. When creating a list of special status plants with the potential to occur in a project area, special care should be taken to search all quads with similar geology, habitats, and vegetation to those found in the project area.

Timing and Number of Visits

Conduct botanical field surveys in the field at the times of year when plants will be both evident and identifiable. Usually this is during flowering or fruiting. Space botanical field survey visits throughout the growing season to accurately determine what plants exist in the project area. This usually involves multiple visits to the project area (e.g. in early, mid, and late-season) to capture the floristic diversity at a level necessary to determine if special status plants are present[13]. The timing and number of visits necessary to determine if special status plants are present is determined by geographic location, the natural communities present, and the weather patterns of the year(s) in which botanical field surveys are conducted.

Reference Sites

When special status plants are known to occur in the type(s) of habitat present in a project area, observe reference sites (nearby accessible occurrences of the plants) to determine whether those special status plants are identifiable at the times of year the botanical field surveys take place and to obtain a visual image of the special status plants, associated habitat, and associated natural communities.

Use of Existing Surveys

For some project areas, floristic inventories or botanical survey reports may already exist. Additional botanical field surveys may be necessary for one or more of the following reasons:

- Botanical field surveys are not current[14];
- Botanical field surveys were conducted in natural systems that commonly experience year to year fluctuations such as periods of drought or flooding (e.g. vernal pool habitats or riverine systems);
- Botanical field surveys did not cover the entire project area;
- Botanical field surveys did not occur at the appropriate times of year;
- Botanical field surveys were not conducted for a sufficient number of years to detect plants that are not evident and identifiable every year (e.g. geophytes, annuals and some short-lived plants);

[13] U.S. Fish and Wildlife Service Guidelines for Conducting and Reporting Botanical Inventories for Federally Listed, Proposed and Candidate Plants available at: https://www.fws.gov/sacramento/es/Survey-Protocols-Guidelines/

[14] Habitats, such as grasslands or desert plant communities that have annual and short-lived perennial plants as major floristic components may require yearly surveys to accurately document baseline conditions for purposes of impact assessment. In forested areas, however, surveys at intervals of five years may adequately represent current conditions. For forested areas, refer to “Guidelines for Conservation of Sensitive Plant Resources Within the Timber Harvest Review Process and During Timber Harvesting Operations”, available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=116396&inline

- Botanical field surveys did not identify all plants in the project area to the taxonomic level necessary to determine rarity and listing status;
- Fire history, land use, or the physical or climatic conditions of the project area have changed since the last botanical field survey was conducted;
- Changes in vegetation or plant distribution have occurred since the last botanical field surveys were conducted, such as those related to habitat alteration, fluctuations in abundance, invasive species, seed bank dynamics, or other factors; or
- Recent taxonomic studies, status reviews or other scientific information has resulted in a revised understanding of the special status plants with potential to occur in the project area.

Negative Surveys

Adverse conditions from yearly weather patterns may prevent botanical field surveyor from determining the presence of, or accurately identifying, some special status plants in the project area. Disease, drought, predation, fire, herbivory or other disturbance may also preclude the presence or identification of special status plants in any given year. Discuss all adverse conditions in the botanical survey report[15].

The failure to locate a known special status plant occurrence during one field season does not constitute evidence that the plant occurrence no longer exists at a location, particularly if adverse conditions are present. For example, botanical field surveys over a number of years may be necessary if the special status plant is an annual or short-lived plant having a persistent, long-lived seed bank and populations of the plant are known to not germinate every year. Visiting the project area in more than one year increases the likelihood of detecting special status plants, particularly if conditions change. To further substantiate negative findings for a known occurrence, a visit to a nearby reference site may help ensure that the timing of botanical field surveys was appropriate.

3. REPORTING AND DATA COLLECTION

Adequate information about special status plants and sensitive natural communities present in a project area will enable reviewing agencies and the public to effectively assess potential impacts to special status plants and sensitive natural communities and will guide the development of avoidance, minimization, and mitigation measures. The information necessary to assess impacts to special status plants and sensitive natural communities is described below. For comprehensive, systematic botanical field surveys where no special status plants or sensitive natural communities were found, reporting

and data collection responsibilities for botanical field surveyor remain as described

[15] U.S. Fish and Wildlife Service Guidelines for Conducting and Reporting Botanical Inventories for Federally Listed, Proposed and Candidate Plants available at: https://www.fws.gov/sacramento/es/Survey-Protocols-Guidelines/

below, excluding specific occurrence information.

Special Status Plant and Sensitive Natural Community Observations

Record the following information for locations of each special status plant and sensitive natural community detected during a botanical field survey of a project area.

- The specific geographic locations where the special status plants and sensitive natural communities were found. Preferably this will be done by use of global positioning system (GPS) and include the datum[16] in which the spatial data was collected and any uncertainty or error associated with the data. If GPS is not available, a detailed map (1:24,000 or larger) showing locations and boundaries of each special status plant population and sensitive natural community in relation to the project area is acceptable. Mark occurrences and boundaries as accurately as possible;
- The site-specific characteristics of occurrences, such as associated species, habitat and microhabitat, structure of vegetation, topographic features, soil type, texture, and soil parent material. If a special status plant is associated with a wetland, provide a description of the direction of flow and integrity of surface or subsurface hydrology and adjacent off-site hydrological influences as appropriate;
- The number of individuals in each special status plant population as counted (if population is small) or estimated (if population is large);
- If applicable, information about the percentage of each special status plant in each life stage such as seedling, vegetative, flowering and fruiting;
- The density of special status plants, identifying areas of relatively high, medium and low density of each special status plant in the project area; and
- Digital images of special status plants and sensitive natural communities in the project area, with diagnostic features.

Special Status Plant and Sensitive Natural Community Documentation

When a special status plant is located, data must be submitted to the CNDDB. Data may be submitted in a variety of formats depending on the amount and type of data that is collected[17]. The most common way to submit data is the Online CNDDB Field Survey Form[18], or equivalent written report, accompanied by geographic locality information (GPS coordinates, GIS shapefiles, KML files, topographic map, etc.). Data submitted in digital form must include the datum[19] in which it was collected.

If a sensitive natural community is found in a project area, document it with a Combined

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16 NAD83, NAD27 or WGS84

17 See https://www.wildlife.ca.gov/Data/CNDDB/Submitting-Data for information on acceptable data submission formats.

18 Available at: https://www.wildlife.ca.gov/Data/CNDDB/Submitting-Data

19 NAD83, NAD27 or WGS84

Vegetation Rapid Assessment and Relevé Field Form[20] and submit the form to VegCAMP[21].

Voucher Collection

Voucher specimens provide verifiable documentation of special status plant presence and identification and a scientific record. This information is vital to conservation efforts and valuable for scientific research. Collection of voucher specimens should be conducted in a manner that is consistent with conservation ethics, and in accordance with applicable state and federal permit requirements (e.g. scientific, educational, or management permits pursuant to Fish & G. Code, § 2081, subd. (a)). Voucher collections of special status plants (or possible special status plants) should only be made when such actions would not jeopardize the continued existence of the population. A plant voucher collecting permit[22] is required from CDFW prior to the take or possession of a state-listed plant for voucher collection purposes, and the permittee must comply with all permit conditions.

Voucher specimens should be deposited in herbaria that are members of the Consortium of California Herbaria[23] no later than 120 days after the collections have been made. Digital imagery can be used to supplement plant identification and document habitat. Record all relevant collector names and permit numbers on specimen labels (if applicable).

Botanical Survey Reports

Botanical survey reports provide an important record of botanical field survey results and project area conditions. Botanical survey reports containing the following information should be prepared whenever botanical field surveys take place, and should also be submitted with project environmental documents:

Project and location description

- A description of the proposed project;
- A detailed map of the project area that identifies topographic and landscape features and includes a north arrow and bar scale;
- A vegetation map of the project area using Survey of California Vegetation Classification and Mapping Standards[24] at a thematic and spatial scale that allows the display of all sensitive natural communities;
- A soil map of the project area; and

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20 Available at: https://www.wildlife.ca.gov/Data/VegCAMP/Natural-Communities/Submit

21 Combined Vegetation Rapid Assessment and Releve Field Forms can be emailed to VegCAMP staff. Contact information available at: https://www.wildlife.ca.gov/Data/VegCAMP/Natural-Communities/Other-Info

22 Applications available at: https://www.wildlife.ca.gov/Conservation/Plants/Permits

23 A list of Consortium of California Herbaria participants is available at: http://ucjeps.berkeley.edu/consortium/participants.html

24 Available at: https://www.wildlife.ca.gov/data/vegcamp/publications-and-protocols

- A written description of the biological setting, including all natural communities; geological and hydrological characteristics; and land use or management history.

Detailed description of survey methodology and results

- Names and qualifications of botanical field surveyor(s);
- Dates of botanical field surveys (indicating the botanical field surveyor(s) that surveyed each area on each survey date), and total person-hours spent;
- A discussion of the survey preparation methodology;
- A list of special status plants and sensitive natural communities with potential to occur in the region;
- Description(s) of reference site(s), if visited, and the phenological development of special status plant(s) at those reference sites;
- A description and map of the area surveyed relative to the project area;
- A list of all plant taxa occurring in the project area, with all taxa identified to the taxonomic level necessary to determine whether or not they are a special status plant;
- Detailed data and maps for all special status plants and sensitive natural communities detected. Information specified above under the headings "Special Status Plant and Sensitive Natural Community Observations," and "Special Status Plant and Sensitive Natural Community Documentation," should be provided for the locations of each special status plant and sensitive natural community detected. Copies of all California Native Species Field Survey Forms and Combined Vegetation Rapid Assessment and Relevé Field Forms should be sent to the CNDDB and VegCAMP, respectively, and included in the project environmental document as an Appendix[25];
- A discussion of the potential for a false negative botanical field survey;
- A discussion of how climatic conditions may have affected the botanical field survey results;
- A discussion of how the timing of botanical field surveys may affect the comprehensiveness of botanical field surveys;
- Any use of existing botanical field surveys and a discussion of their applicability to the project;
- The deposition locations of voucher specimens, if collected; and
- A list of references used, including persons contacted and herbaria visited.

[25] It is not necessary to submit entire environmental documents to the CNDDB

Assessment of potential project impacts

- A discussion of the significance of special status plant populations in the project area considering nearby populations and total range and distribution;
- A discussion of the significance of sensitive natural communities in the project area considering nearby occurrences and natural community distribution;
- A discussion of project related direct, indirect, and cumulative impacts to special status plants and sensitive natural communities;
- A discussion of the degree and immediacy of all threats to special status plants and sensitive natural communities, including those from invasive species;
- A discussion of the degree of impact, if any, of the project on unoccupied, potential habitat for special status plants; and
- Recommended measures to avoid, minimize, or mitigate impacts to special status plants and sensitive natural communities.

4. BOTANICAL FIELD SURVEYOR QUALIFICATIONS

Botanical field surveyors should possess the following qualifications:

- Knowledge of plant taxonomy and natural community ecology;
- Familiarity with plants of the region, including special status plants;
- Familiarity with natural communities of the region, including sensitive natural communities;
- Experience with the CNDDB, BIOS, and Survey of California Vegetation Classification and Mapping Standards;
- Experience conducting floristic botanical field surveys as described in this document, or experience conducting such botanical field surveys under the direction of an experienced botanical field surveyor;
- Familiarity with federal, state, and local statutes and regulations related to plants and plant collecting; and
- Experience analyzing the impacts of projects on native plant species and sensitive natural communities.

5. SUGGESTED REFERENCES

Bonham, C.D. 1988. Measurements for terrestrial vegetation. John Wiley and Sons, Inc., New York, NY.

California Native Plant Society, Rare Plant Program. Most recent version. Inventory of rare and endangered plants (online edition). California Native Plant Society. Sacramento, CA. Available at: http://www.rareplants.cnps.org/.

California Native Plant Society. Most recent version. A manual of California vegetation. California Native Plant Society. Sacramento, CA. Available at: http://www.cnps.org/cnps/vegetation/manual.php.

California Department of Fish and Wildlife, California Natural Diversity Database. Most recent version. Special vascular plants, bryophytes and lichens list. Updated quarterly. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109383&inline.

Elzinga, C.L., D.W. Salzer, and J. Willoughby. 1998. Measuring and monitoring plant populations. BLM Technical Reference 1730-1. U.S. Dept. of the Interior, Bureau of Land Management. Denver, Colorado. Available at: https://www.blm.gov/nstc/library/pdf/MeasAndMon.pdf.

Jepson Flora Project (eds.) Most recent version. Jepson eFlora. Available at: http://ucjeps.berkeley.edu/eflora/.

Leppig, G. and J.W. White. 2006. Conservation of peripheral plant populations in California. Madroño. 53:264-274.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, Inc. New York, NY.

U.S. Fish and Wildlife Service. 1996. Guidelines for conducting and reporting botanical inventories for federally listed plants on the Santa Rosa Plain. Sacramento, CA.

U.S. Fish and Wildlife Service. 1996. Guidelines for conducting and reporting botanical inventories for federally listed, proposed and candidate plants. Sacramento, CA.

Van der Maarel, E. 2005. Vegetation Ecology. Blackwell Science Ltd. Malden, MA.

This document is available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18959&inline

ATTACHMENT C

WHITELEAF MANZANITA

Arctostaphylos manzanita Parry

Plant Symbol = ARMA

Common Names: Common manzanita
Scientific Names: *A. manzanita* Parry ssp. *elegans* (Eastw.) P.V. Wells, *A. manzanita* Parry ssp. *glaucescens* P.V. Wells, *A. manzanita* Parry ssp. *laevigata* (Eastw.) Munz, *A. manzanita* Parry ssp. *manzanita, A. manzanita* Parry ssp. *roofii* (Gankin) P.V. Wells, *A. manzanita* Parry ssp. *wieslanderi* P.V. Wells

Figure 1. Whiteleaf manzanita trees growing in the Sierra Foothills in California. Photo: USDA, Lockeford Plant Materials Center.

Description
General: The genus *Arctostaphylos* consists of trees and shrubs in the Ericaceae family, with the majority native to California, characterized by reddish bark and, evergreen leaves. (Stuart and Sawyer, 2001). Different manzanita species often hybridize causing identification to species to be difficult when distribution and habitats overlap (Abrahamson, 2014; Parker et al., 2012; Stuart and Sawyer, 2001). Whiteleaf manzanita is an erect and spreading, tree-like shrub growing from 6 to 25 feet in height (Figure 1). The stems and twigs are mahogany colored, smooth and hairless. The leaves are erect, entire, and flat with a petiole, the leaf blade is oblong-ovate to obovate 1 -2 inches in length and 0.4 -1.4 inches in width. The leaves are evergreen although the shade can vary from bright green to greyish or blueish green and may be shiny or dull. The surface of the leaf can be smooth and hairless or have stiff hairs, veins are non-glandular but may have hairs, the leaf tip is acute, and the leaf margin is entire (Figure 2). The flowers on whiteleaf manzanita are arranged on a panicle with 2 – 7 branches that hang down and subtend the flowers. The flower shape is round with five white to pinkish lobes, often referred to as urn or bell shaped(Parker et al., 2012). The flowering period is from January to March (Calflora, 2018). The fruit are berry-like drupes, spherical, 0.3 – 0.5 inches in diameter and resemble tiny apples (the Spanish name for apple is *manzana*). Seed production is typically abundant, and fruits ripen from early to late summer through early fall and remain on the tree (Parker et al., 2012; Stuart and Sawyer, 2001). The fruits contain 3 to 4 seeds protected by a dense impervious layer of tissues derived from the flower (Abrahamson, 2014). Common manzanita may have a tap root, but older plants typically have a shallow root system (Abrahamson, 2014).

There are currently six recognized subspecies with limited distribution areas apart from the type subspecies:

- *manzanita* ssp. *elegans*, Konocti manzanita. Limited to the North Coast and Klamath Ranges, blooms from February through May, and stones in the fruit are generally fused (Calflora, 2018: Parker et al., 2012).
- *manzanita* ssp. *glaucescens*, Whiteleaf manzanita. This subspecies is limited to the Outer North Coast Range, it blooms from February through May, the stones in the fruit are free (Calflora, 2018: Parker et al., 2012).
- *manzanita* ssp. *laevigata* Contra Costa manzanita. This subspecies is limited to the Vaca Mountains of the North Coast Range and around Mount Diablo located on the east of the San Francisco Bay. The leaves are shiny and bright green, with 2-4 pinkish white flowers to each panicle and the stones free in the drupe. Bloom is from February through May (Calflora, 2018: Parker et al., 2012).
- *manzanita* ssp. *manzanita,* Whiteleaf manzanita. The most common of the subspecies, variable and found throughout the range. Leaf color varies from bright green to dull. Stones are free (Calflora, 2018: Parker et al., 2012).
- *manzanita* ssp. *roofii*, Roof’s manzanita. This subspecies is limited to the Interior North Coast Ranges and Cascade Range Foothills, with one occurrence further south in Butte County. There is a prominent burl at the base of the stem, which makes the plant more resistant to fire. Bloom is from February through May. Stones are free or partly fused in the fruit (Calflora, 2018: Parker et al., 2012).

- *manzanita* ssp. *wieslanderi*, Wieslander's manzanita. This subspecies is limited to the High North Coast Ranges and the Cascade Range Foothills. The leaves are dull green, scabrous and glandular hairy. Stones are free, and bloom is from February through May (Calflora, 2018: Parker et al., 2012).

Description

Distribution: Whiteleaf manzanita is endemic to California, although most subspecies have limited distributions, the type subspecies *A. manzanita* ssp. *manzanita*, is found from the North Coast Ranges, eastward to the Cascade Range and Sierra Nevada foothills at elevations of 100 to 4,900 feet (Abrahamson, 2014; Parker et al., 2012). For current distribution, please consult the Plant Profile page for this species on the PLANTS Website.

Figure 2. Whiteleaf manzanita in bloom in the Sierra Foothills, January 2018. Photo: USDA, Lockeford Plant Materials Center.

Habitat: Whiteleaf Manzanita is found in chaparral, foothill woodland, especially blue oak, *Quercus douglasii,* woodland, Northern oak woodland and yellow-pine forests, and redwood-Douglas fir in the inland North Coast ranges. It occurs on rocky slopes, woodlands, coniferous forest, sandstone outcrops, shale outcrops, subalpine forest, serpentine soils, ridges and open areas (Abrahamson, 2014; CalFlora, 2018; Parker et al., 2012).

Adaptation: Whiteleaf manzanita grows on a variety of soil types including, sand, clay, and occasionally serpentine soils. They tolerate poor soils and xeric conditions and are most common on dry rocky sites (Abrahamson, 2014; Parker et al., 2009). The plants are fire adapted, although a moderate fire will kill the plants. Fire also activates seed in the seed bank to germinate. The plants require full sun, seedling recruitment is poor in shaded situations. Whiteleaf manzanita plants are strongly mycorrhizal with ectomycorrhizal associations supporting their growth in poor soils (Acsai and Largent, 1983). It is an associated species in most communities, but in areas such as the Napa Ranges and the middle, upper, and North Coast Ranges, it may form closed impenetrable thickets of forest-like growth (Abrahamson, 2014).

Uses

Wildlife: Whiteleaf manzanita is an important plant for California Wildlife. The plants provide cover and browse for deer, although the nutritional value of the leaves and twigs is low, especially new growth in spring (Sampson and Jesperson, 1963). The flowers produce nectar and are visited by native bees and other beneficial insects, making whiteleaf manzanita a suitable early blooming hedgerow plant (Earnshaw, 2018; Mader, 2011). The fruit provides wildlife food over the summer and fall including deer, raccoon, skunks, ground squirrels, coyote, and bears (Abrahamson, 2014; Reed, 2006). The plants provide cover and insect forage to numerous bird species (Abrahamson, 2014; Sibley, 2000).

Ornamental: Whiteleaf manzanita is an attractive ornamental plant, with its mahogany colored trunks and stems, green foliage throughout the year, and beautiful whitish pink flowers in early spring. It is very drought tolerant (Theodore Payne, 2014). Several cultivars are available commercially.

Ethnobotany

Whiteleaf manzanita is a culturally significant multiple uses plant for the native tribes in California. The berries are highly valued for making a cider drink, food, medicinal properties. The wood is valuable for making tools and utensils and is excellent firewood. The berries were collected from the manzanita bush by hand picking into burden baskets that were hung around the neck or by using flat sifting baskets placed underneath the shrub. The branches would then be shaken, and the berries would collect into the baskets (Barrett and Gifford, 1933; Dubois, 1935).

Many California tribes including the Karok, Maidu, Miwok, Wintu, and Yuki made a delicious cider from the berries (Barrett and Gifford, 1933; Chestnut, 1902; Durbin and Tolley, 2008; Merriam 1967, Schenk and Gifford, 1952). In making cider, the berries were crushed, and an equal volume of water was poured over the crushed berries. The mixture was poured into a straining basket (sometimes with an additional layer of pine needles or dry grass), to be collected into a waterproof basket below (Figure 3) (Chestnut, 1902). If any of the berries passed through, the liquid would be decanted (Barrett and Gifford, 1933; Du Bois, 1935). The Indians at Chowchilla filtered manzanita cider using deep round openwork bowl baskets (Merriam, 1955). The beverage would keep without souring for up to four days. The cider was sweet and drunk before fermentation because fermentation would make it sour (Barrett and Gifford, 1933; Du Bois, 1935). A modern recipe simmers green berries for 15 minutes, bruising, leaving overnight and then decanting, sweetening with honey if needed (Dubin and Tolley, 2008).

The berries were eaten raw in limited amounts as they are tart and indigestible, although valuable to suppress thirst (Chestnut, 1902). Tribes in the Yosemite region chewed the berries for flavor, but did not swallow them (Barrett and Gifford, 1933). Elders remember drinking the sweet juice straight from pounding holes while lying on their stomachs as children (Bibby and Aquilar, 2005). The Maidu pounded the berries in mortars and ate them without other treatment (Merriam 1967). The Yuki ate the ripe berries raw and parched and used them with ground seeds of other plants in pinole (Curtin, 1957). The ground manzanita berries were a staple food, used as a pinole, a porridge and a bread and dried and stored for winter for many tribes including the Numlaki and Wintu (Chestnut, 1902; Harrington, and Bocek, 1984). Anthropologist Cora Du Bois (1935) describes the processing and cooking of the berries among the Wintu: "Berries pounded into coarse flour, dampened, next morning dried and parched with hot rocks. Winnowed. Fine flour boiled with water and made into sweetish soup". The Karok dried the berries in the sun then stored them in baskets, the dried berries were sometimes pounded with salmon eggs and cooked in baskets with hot rocks (Schenk and Gifford, 1952).

Whiteleaf manzanita was also used medicinally among Native American tribes. The Wintu and Pomo tribes used the leaves in tea to alleviate diarrhea and they soaked the leaves to relieve poison oak symptoms, cold symptoms, and headaches (Chestnut, 1902). The Miwok tribes chewed the leaves to help ease pain associated with cramps and stomachaches (Barrett and Gifford, 1933). The Concow applied a poultice of the chewed leaves to sores (Chestnut, 1902).

The wood of Whiteleaf manzanita is strong and was used for tools, such as spoons, scraping sticks for acorn soup and reels for sting, walking and carrying sticks (Schenk and Gifford, 1952). Chestnut (1902) reports that some tribes including the Yuki and Pomo used two V- shaped pieces, about a yard in height and curved on one side, for carrying large loads of wood. The pieces were stacked onto the forks, then the straight pieces were grasped with both hands and slung onto the back. This allowed carrying of heavy loads of wood. Manzanita wood makes excellent firewood, burning hot and steadily, it burns fast and so was usually burned with more slowly burning wood, such as oak (Chestnut, 1902). Manzanita wood is recommended today for smoking and cooking both fish and meats (Dubin and Tolley, 2008).

Indigenous stewardship method traditionally used for management of this plant is frequent cool temperature prescribed burns. Today these burns are typically carried out after fall rains, so that the flames proceed slowly through the dead grasses and herbaceous vegetation. Whiteleaf manzanita continues to be locally abundant, apart from the subspecies with limited distribution (Parker et al., 2012).

Status

Threatened or Endangered: Two whiteleaf manzanita subspecies are listed by the California Native Plant Society Rare Plant Bank: *A. manzanita* ssp. *elegans*, Konocti manzanita is ranked 1B.3 and *A. manzanita* ssp. *laevigata* Contra Costa manzanita as 1B.2. This listing includes plants rare, threatened, or endangered in California and elsewhere.

Weedy or Invasive: This plant may become weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed. Please consult with your local NRCS Field Office, Cooperative Extension Service office, state natural resource, or state agriculture department regarding its status and use.

Please consult the PLANTS Web site (http://plants.usda.gov/) and your state's Department of Natural Resources for this plant's current status (e.g., threatened or endangered species, state noxious status, and wetland indicator values).

Planting Guidelines

Germination of whiteleaf manzanita seeds is generally poor without scarification and fire (Berg, 1974). Container grown plants of whiteleaf manzanita should be transplanted with fall rains and provided with limited irrigation for the first two years until established.

Management

Whiteleaf manzanita is a fire adapted plant with estimated burn intervals of 30 to 50 years. A moderate intensity burn will kill the plants but also activate seed to germinate in the year following the fire. A high intensity burn may not only kill the plants but also the seeds, if the temperatures in the soil are hot enough (Abrahamson, 2014).

Pests and Potential Problems

Whiteleaf manzanita is regulated as a host to Sudden Oak Death, *Phytophthora ramorum* (USDA APHIS, 2013). Symptoms of the disease include lesions on leaves and stems are found in the field and these have been duplicated on plants in the laboratory (Davidson et al., 2003; Rizzo and Garbelotto, 2003).

Environmental Concerns

Whiteleaf manzanita stands are highly flammable, due to the resinous leaves and hot burning wood (Abrahamson, 2014). Brush removal is often advised for fire suppression around buildings and for Forest Management.

Control
Please contact your local agricultural extension specialist or county weed specialist to learn what works best in your area and how to use it safely. Always read label and safety instructions for each control method. Trade names and control measures appear in this document only to provide specific information. USDA NRCS does not guarantee or warranty the products and control methods named, and other products may be equally effective.

Seeds and Plant Production
Fruits are collected from the plants by hand or picked up off the ground. The outer fleshy part of the fruit must be macerated and separated from the seeds. *Arctostaphylos* spp. have hard seed coats and dormant embryos. Under natural conditions dormancy is broken by fire, and treatments such as sulfuric acid scarification or simulated burning under pine needles is required to break dormancy (Berg, 1974). Seedlings planted in flats may be transplanted to containers and planted out with fall rains. Manzanita are easier to propagate from cuttings than from seed. For vegetative propagation, cut the semi-mature previous season's growth between December and January. "Treat with a hormone solution for 10 seconds. Place in medium that is 1 peat: 10 perlite rooting mix" (Hart, 2005). Place in a shaded area outside, mist and water as necessary. After roots have established, place in a medium of "1 sand: 7 peat: 7 perlite." Whiteleaf manzanita requires proper drainage and aeration in the soil.

Cultivars, Improved, and Selected Materials (and area of origin)
There are three named cultivars: from the Napa Area of California 'Byrd Hill' is a compact form growing no more than 8 feet tall and 'Saint Helena' collected from Mount St Helena is slightly larger growing to 10 feet tall, 'Dr. Hurd' grows taller to 15 feet tall and originates from Saratoga, to the south of the San Francisco Bay (Theodore Payne, 2014).

Literature Cited

Abrahamson, I. 2014. *Arctostaphylos manzanita*. In: Fire Effects Information System [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Available: http://www.fs.fed.us/database/feis/plants/shrub/arcman/all.html. Accessed: January 22, 2018.

Acsai, J. and D.L. Largent, 1983. Mycorrhizae of *Arbutus menziesii* Pursh. and *Arctostaphylos manzanita* Parry in northern California. Mycotaxon. 16. 519-36.

Barrett, S.A., and E.W. Gifford. 1933. Indian life of the Yosemite region, Miwok material culture. Bull. of Milwaukee Public Museum 2(4) 11:161-162.

Berg, A.R. 1974. Arctostaphylos, Manzanita. In: Seeds of Woody Plants of the United States. Forest Service, USDA Agriculture Handbook No. 450.

Bibby, B., and D. Aguilar. 2005. Deeper Than Gold: A Guide to Indian Life in the Sierra Foothills. Berkeley, Calif.: Heyday Books.

Calflora: Information on California plants with data contributed by public and private institutions and individuals, including the Consortium of California Herbaria. [web application]. 2018. Berkeley, California: The Calflora Database [a non-profit organization]. Available: http://www.calflora.org/ (Accessed: Jan 25, 2018).

Chestnut, V.K. 1902. Plants used by the Indians of Mendocino County, California. Contributions from the U.S. National Herbarium. 7:294-408.

Curtin, L.S.M., 1957. Some plants used by the Yuki Indians II. Food Plants, The Masterkey 31:85-94.

Dubin, M. and S.-L. Tolley (Eds.). 2008. Seaweed, salmon and Manzanita cider: A California Indian feast. Heyday Institute

Du Bois, C.A., 1935. Wintu ethnography. American Archaeology and Ethnology 36(1). University of California Publications.

Earnshaw, S. 2018. Hedgerows and Farmscaping for California Agriculture; A Resource Guide for Farmers. 2nd Edition. https://www.caff.org/resources/on-farm-sustainability/ (Accessed on April 13, 2018).

Harrington, J.P. and B.R. Bocek., 1984. Ethnobotany of Costanoan Indians, California. Economic Botany 38(2). New York Botanical Gardens, NY, NY.

Hart, L., 2005. Propogation and cultivation of *Arctostaphylos* in relation to the environment in its natural habitat in California. Combined Proceedings International Plant Propagators' Society 55.

Mader, E., M. Shepherd, M. Vaughan, S.H. Black, G. LeBuhn. 2011. Attracting Native Pollinators. The Xerces Society, Storey Publishing North Adams, MA. 373pp.

Merriam, C.H. 1967. Ethnographic notes on California Indian tribes. III. Ethnological notes on central California Indian tribes. Compiled and Edited by R.F. Heizer. Reports of the California Archaeological Survey No. 68, Part III. University of California Archaeological Research Facility, Dept. of Anthropology, Berkeley.

Merriam, C.H., 1955. Studies of California Indians. University of California Press, Berkeley, CA.

Parker, V.T., M. C. Vasey & J. E. Keeley. 2012, *Arctostaphylos manzanita*, in Jepson Flora Project (eds.) Jepson eFlora, http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=13942, (accessed on January 24, 2018).

Parker, V.T., M. C. Vasey & J. E. Keeley.2009. Arctostaphylos in Flora of North America@efloras.org (Accessed: February 13, 2018).

Reed, F.A., 2006. Peterson's field guides, mammals of North America. Houghton Mifflin Co., NY, NY.

Rizzo D.M. and M. Garbelotto, 2003. Sudden oak death: endangering California and Oregon forest ecosystems. Front. Eco. Environ. 1:197-204.
Sampson, A.W. and B.S. Jespersen. 1963. California range brushlands and browse plants. Berkeley. CA. University of California, Division of Agricultural Sciences; California Agricultural Experiment Station, Extension Service. 162p.
Schenk, S.M. and E.W. Gifford. 1952. Karok Ethnobotany. Anthropological Records 13:377-392.
Sibley, D.L., 2000. The Sibley guide to birds. Chanticleer Press, Inc., NY, NY.
Stuart, J.D. and J.O. Sawyer., 2001. Trees and shrubs of California. University of California Press, Berkeley, CA.
Theodore Payne Foundation for Wild Flowers and Native Plants. 2014. Sun Valley, CA http://theodorepayne.org/ (Accessed February 5, 2018).
USDA APHIS. 2013. List of Regulated Hosts and Plants Proven or Associated with *Phytophthora ramorum*. https://www.aphis.usda.gov/plant_health/plant_pest_info/pram/downloads/pdf_files/usdaprlist.pdf (Accessed April 25, 2018).

Citation

Smither-Kopperl, M.L. 2018. Plant Guide for whiteleaf manzanita (*Arctostaphylos manzanita)*. USDA-Natural Resources Conservation Service, Lockeford Plant Materials Center. Lockeford, CA 95237.

Published: September, 2018

For more information about this and other plants, please contact your local NRCS field office or Conservation District at http://www.nrcs.usda.gov/ and visit the PLANTS Web site at http://plants.usda.gov/ or the Plant Materials Program Web site: http://plant-materials.nrcs.usda.gov.

ATTACHMENT D

Inventory & Monitoring Protocols – Bats			
Survey Level	**Questions**	**Methods**	**Products**
Preliminary (office-oriented)	• What bats are known to occur, or could potentially occur, in the unit? • What habitat features at the unit are known to support, or might support, bats?	• Conduct literature and database searches **(1, 2, 3, 4, 5)** • Consult with knowledgeable persons (park maintenance and other staff, etc.) and agencies **(3, 4)** • Review any existing documents on habitat features (geologic, biotic, hydrologic, anthropogenic/facilities) for the site (Unit data file) • •	• A list of bat species that occur, or could occur, in the unit based upon their habitat affinities and ranges, and an idea of where habitat features might be located.
Reconnaissance (field-oriented)	• What habitat features (e.g. mines, caves, water sources, wildlife trees, etc.) that exist at the unit may be used by bats, and where are they located? • What bats are known to occur at the unit and where are they located? • Is there an apparent change in use or the used habitat feature compared to previous years?	• Determine potential use areas or changes in potential use areas/features by looking for sign or animals at high potential geologic and anthropogenic roosts during the day and night (Do not knowingly disturb a colony) **(6, 7, 8, 9, 11)** • Use bat detectors and/or night vision at potential roost sites, in predicted high use areas, or along roads and trails at night **(10)** • **Methods Do Not Necessarily Require Special Permits**	• Completed annual inspection & questionnaire • Rapid assessment of bat use or potential change in use
Baseline (field-oriented)	• What bat species are using the unit, and what areas and features are being used? • Where are the occupied roosts and use areas/features? • What is the colony size of occupied roosts? • Is there a change in use or the used habitat feature compared to previous years?	• Methods outlined in the Preliminary and Recon Level plus: Conduct out flight surveys and counts at dusk - count with night vision, backlight or red light, mist-net or harp trap (qualified bat biologist only for captures), and take Anabat recordings **(6, 7, 8, 10, 11)** • Conduct roost entry surveys where feasible (day and night), identification by sight or hand net and count (by qualified bat biologist only) **(6, 7, 9, 12)** • Conduct stationary point surveys with mist net/harp trap (qualified bat biologist only) and Anabat at predicted high use areas (primarily over surface water and across flyways) **(6, 10, 11).** • Use Global Positioning System (GPS) to create a map of bat roosts and survey locations as points. • Take photos of roost sites and make general observations of the site using Roost data sheet. • Take photos of individual bats to represent each species as voucher (The state does not allow collection of voucher specimens of bats without it being specifically authorized in a permit, except for salvage). • Have experts verify the identification of taxa that are in question by having them look at voucher photo, Anabat recordings, or the bats *in situ*. • Repeat the above periodically and compare results to previous years (Monitoring). • **Roost Entry and Capture Requires Special Permits from DFG**	• A list of all bat species detected at the unit • A bat call library of recorded calls. • Descriptions of occupied roosts, inhabitants and their location within the unit. • Colony size at occupied diurnal roosts and changes from survey to survey. • Mapped locations of bat use areas and species using them.
Comprehensive	• What are the species assemblages in the various habitats	• Methods outlined in the Preliminary Level plus:	• Products of the Preliminary Level plus:

Inventory & Monitoring Protocols – Bats			
Survey Level	**Questions**	**Methods**	**Products**
(field-oriented)	during different seasons? • How does use change with season or stage in reproductive cycle? • What is the reproductive output from known maternity colonies? • What is the relative number of occupied/unoccupied suitable roosts and estimated total number of individuals roosting at the unit? • What are the threats or impacts to the population? • What are the changes in the above-mentioned attributes over time?	stationary surveys within each habitat type, sampled minimum of 2 nights each, between 1 May and 30 August. **(6, 11)** • Repeat stationary surveys during fall, winter, and/or early spring to determine seasonal use patterns, and presence of migratory or wintering species. • Placement of guano traps below identified roosts (clean and visit every month throughout year) to determine frequency and seasonality of use. • Repeat roost counts during non-summer season, if bats are present. • Repeat the above periodically and compare results to previous years (Monitoring). • **Roost Entry and Capture Requires Special Permits from DFG**	Confirmation of habitat associations and use areas, habitat preferences. • Estimate of relative abundance in each habitat type by species • Seasonal use patterns • Detect changes and trends in the above.
Intensive (field- & laboratory-oriented)	• Questions related to demographics, genetics, energy/nutrient cycling, etc. • How are the population demographics or other attributes changing?	• Methods will be dependent upon the nature of the question and the taxon. Standard protocols, when available and applicable, should be employed. **(12)** • Radio-tracking to find roosts and foraging areas **(6).** • Capture and band roost occupants to track demographics **(6).** • Determine availability of suitable roosts (first have to find and describe), such as estimate of suitable snags per acre, or acres of rock outcrops/cliffs with suitable fractures. • Focus studies to address specific management issues or interrelated factors • Repeat the above periodically and compare results to previous years (Monitoring). • **Roost Entry, Capture, Banding, Radio-tracking and Tissue Sampling Requires Special Permits from DFG**	• Detailed and intensive studies and reports on an attribute of interest with regard to a particular sensitive species or occurrence. • Home range size and movements, use of multiple roosts or foraging areas by a colony or individual. • Location of cryptic roosts • Demographics • Estimate of absolute abundance from locating most roosts and counting colony size. • Suitable maternity roosts characteristics and availability in park • Detect changes and trends in focused attribute.

References:

1) Barbour and Davis 1969. *Bats of America*, Kentucky Press. Out of print book, but available at most libraries. Copies of sections on selected taxa available from Karen Miner, Southern Service Center

2) Brylski et al. In Prep. *Mammal Species of Special Concern in California*. Not yet available, but watch for it from California Department of Fish and Game.

3) California Natural Diversity Database (CNDDB). California Department of Fish and Game. Sacramento, CA 95814 or visit the California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch website at: www.dfg.ca.gov/whdab/html/cnddb.html

4) California Wildlife Habitat Relationship (CWHR). California Department of Fish and Game. Sacramento, CA 95814 or visit the California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch website at: http://www.dfg.ca.gov/whdab/html/cwhr.html

5) Mammalian Species. Comprehensive pamphlets on each species (most species covered). Available from the American Society of Mammalogists. http://www.mammalsociety.org/publications/index.html

6) Kunz, T.H. (Ed.). 1988. *Ecological and Behavioral Methods for the Study of Bats*. Smithsonian Institution Press, Wash. D.C. ISBN 0-87474-411-3. Book available at online bookstores, etc.

7) Altenbach et al.. 1999. *Evaluation of bat use in abandoned mines*. Copies available from IMAP Teams

8) Navo, K. 1995. *Guidelines for external surveys of mines for bat roosts*. Copies available from IMAP Teams

9) American Society of Mammalogists. 1992. *Guidelines for the protection of bat roosts*. Journal of Mammalogy 73(3): 707-710.

10) O'Farrell, M.J., B. W. Miller and W.L. Gannon. 1999. *Qualitative identification of free-flying bats using the Anabat detector*. Journal of Mammalogy, 80:11-23.

11) Province of British Columbia. 1998. *Inventory Methods for Bats: Standards for Components of British Columbia's Biodiversity*, No. 20. Resources Inventory Committee, Available at http://www.for.gov.bc.ca/ric/pubs/TEBIODIV/.

12) Pierson et al. 1999. *Species conservation assessment and conservation strategy for the Townsend's big-eared bat.* Idaho Conservation Effort, Dept of Fish and Game, Idaho. Copies can be obtained from IMAP team or Charles E. Harris, Idaho Dept of Fish and Game, P.O. Box 25, Boise, ID 83707-0025; 208-334-2920; charris@idfg.state.id.us

Also checkout http://www.batcon.org and links for bat species accounts and management

ATTACHMENT E

CNPS California Native Plant Society

Inventory of Rare and Endangered Plants

The Rare, Threatened, and Endangered Plants of California

Glossary of Terms and Field Descriptions
(Adopted and modified from the CNPS Inventory, 6th Edition, 2001)

The heart of the CNPS *Inventory* is our assessment of the current conservation status of each of our state's rare, threatened, and endangered plants. We present these assessments together with a summary of current information on the distribution and ecology of each taxon. We also include entries for plants that were considered but rejected for one or more reasons, as well as other scientific names that have been used in the standard literature or in previous editions of this *Inventory*.

Basis for Inclusion

The vast majority of the taxa in this *Inventory* are vascular plants (ferns, fern allies, gymnosperms, and flowering plants). We also present our evaluation of rarity and endangerment of California's bryophytes (mosses, liverworts, and hornworts). Algae, fungi, and lichens are not treated here.

A plant must be native to California to be included. Ornamentals, plants escaped from cultivation, and naturalized plants are excluded. So are the sporadic hybrids that sometimes occur under natural conditions. The relatively trivial color variants and occasional departures from typical vegetative or floral conditions, referred to by botanists as "forma," are similarly excluded.

This *Inventory* focuses on plants that are rare in California. A very small number of plants that are still somewhat common in California are included because they are in decline and face further immediate threats. We recognize that extensive habitat alteration and pervasive human impacts pose serious threats to many other species that are still common. However, evaluation of threats to species that are neither rare nor imminently becoming so is outside the scope of this *Inventory*. By limiting our scope in this way, we in no way imply that these species are not of concern.

Scientific Names

The plants in this *Inventory* are presented by their scientific names which have been properly published according to the *International Code of Botanical Nomenclature*. See Shevock (1993)[10] for a general discussion of nomenclature.

In its simplest form, a scientific name has three parts. The first is the genus name. It is always capitalized. The second part is the specific epithet, often incorrectly called "the species name." Together, these two components make up the species name. If a scientific name is presented in its most complete form, these two words will be followed by the names of one or more persons, often in an abbreviated form, who first published the specific epithet or subsequently published a taxonomic modification of the plant. These names are the authorities. If a portion of an authority occurs within parentheses, then the author in parentheses originally placed the epithet in a different genus or species, or once assigned it to a different taxonomic rank. The name cited outside the parentheses is that of the person who published the combination as it now appears.

Often the scientific name is more complex because botanists have recognized categories below the level of species. The two most useful are the subspecies (abbreviated ssp.) and the variety (abbreviated var.) These names are also displayed according the *International Code* and they have their own authorities.

Consider the example *Penstemon newberryi* Gray var. *sonomensis* (Greene) Jeps. *Penstemon* is the genus name; *newberryi* is the specific epithet; Gray, for Asa Gray, is the author of the specific epithet; var. is the abbreviation for variety; *sonomensis* is the subspecific epithet; (Greene), for Edward L. Greene, first described the var. *sonomensis* as a full species; and Jeps., for Willis Lynn Jepson, modified its taxonomic position and made it a variety of *P. newberryi*. Following the general practice for foreign words and phrases, Latin portions of the name (genus, species, and infraspecific epithet) are typically distinguished from surrounding text with underlining or italic typeface.

Nomenclatural Usage

We use what we consider to be the current, best nomenclature based on the recommendations of the Rare Plant Program Committee and consultation with taxonomic authorities. Many names in this *Inventory* have been in use for a long time, appearing in Munz (1959, 1968, 1974)[7][8][9] and Abrams (1923-1960)[1]. Others have been introduced or reintroduced to us in The Jepson Manual (1993)[4] and The Jepson Online Interchange, or described new to science in the last several years.

The usage in this *Inventory* does not follow any single published source, though if other considerations are equal, we use the names found in The Jepson Manual and/or on their Online Interchange. When the nomenclature we use varies from that of The Jepson Manual, we include information in the Notes section of each entry describing the situation. See Skinner and Ertter (1993)[11] for a discussion of taxonomic coordination between the *Inventory* and The Jepson Manual.

Where there is disagreement among experts on taxonomic distinctiveness, we lean towards recognizing doubtfully distinct taxa. Such taxa are typically assigned to List 3. By encouraging protection until taxonomic questions are resolved, we hope to reduce ex post facto regret over taxa that have been shown to be distinct only after their disappearance.

We do not include taxa that lack formally published scientific names.

Common Names

Each of the plants has a common or vernacular name. Although the majority of the plants in the *Inventory* have no real common name, we include them because it is often easier for many of us to refer to a plant by a more familiar sounding name. Most of the common names were coined by Leroy Abrams for his Illustrated Flora of the Pacific States. In other instances, we simply follow his lead by contriving names, usually by translating the Latin or Greek roots into English or by selecting an appropriate geographical reference or person's name. We attempt to follow Kartesz and Thieret (1991)[6] in matters of capitalization, spelling, and hyphenation of common names.

Family Names

Each entry includes the technical name of the family to which the plant belongs. Note that all of these names end with the suffix "-aceae." A few plant families have older, alternative names that the *International Code* allows to be used because their widespread acceptance predates formal nomenclature. Gramineae is a perfectly acceptable alternative for Poaceae; Compositae for Asteraceae; Cruciferae for Brassicaceae; Umbelliferae for Apiaceae; Leguminosae for Fabaceae; and Labiatae for Lamiaceae. However, these old names are gradually losing favor, so we use the standardized, modern names for these families.

The CNPS Ranking System

California Rare Plant Rank 1A: Plants Presumed Extirpated in California and Either Rare or Extinct Elsewhere

Plants with a California Rare Plant Rank of 1A are presumed extirpated or extinct because they have not been seen or collected in the wild in California for many years. A plant is extinct if it no longer occurs anywhere. A plant that is extirpated from California has been eliminated from California, but may still occur elsewhere in its range.

All of the plants constituting California Rare Plant Rank 1A meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and are eligible for state listing. Should these taxa be rediscovered, and impacts proposed to individuals or their habitat, they must be analyzed during preparation of environmental documents relating to the California Environmental Quality Act (CEQA), or those considered to be functionally equivalent to CEQA, as they meet the definition of Rare or Endangered under CEQA Guidelines §15125 (c) and/or §15380.

California Rare Plant Rank 1B: Plants Rare, Threatened, or Endangered in California and Elsewhere

Plants with a California Rare Plant Rank of 1B are rare throughout their range with the majority of them endemic to California. Most of the plants that are ranked 1B have declined significantly over the last century. California Rare Plant Rank 1B plants constitute the majority of taxa in the CNPS *Inventory*, with more than 1,000 plants assigned to this category of rarity.

All of the plants constituting California Rare Plant Rank 1B meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and are eligible for state listing. Impacts to these species or their habitat must be analyzed during preparation of environmental documents relating to CEQA, or those considered to be functionally equivalent to CEQA, as they meet the definition of Rare or Endangered under CEQA Guidelines §15125 (c) and/or §15380.

California Rare Plant Rank 2A: Plants Presumed Extirpated in California, But Common Elsewhere

Plants with a California Rare Plant Rank of 2A are presumed extirpated because they have not been observed or documented in California for many years. This list only includes plants that are presumed extirpated in California, but more common elsewhere in their range.

All of the plants constituting California Rare Plant Rank 2A meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and are eligible for state listing. Should these species be rediscovered, any impacts proposed to individuals or their habitat must be analyzed during preparation of environmental documents relating to CEQA, or those considered to be functionally equivalent to CEQA, as they meet the definition of Rare or Endangered under CEQA Guidelines **§**15125 (c) and/or **§**15380.

California Rare Plant Rank 2B: Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere

Except for being common beyond the boundaries of California, plants with a California Rare Plant Rank of 2B would have been ranked 1B. From the federal perspective, plants common in other states or countries are not eligible for consideration under the provisions of the Federal Endangered Species Act. With California Rare Plant Rank 2B, we recognize the importance of protecting the geographic range of widespread species. In this way we protect the diversity of our own state's flora and help maintain evolutionary processes and genetic diversity within species.

All of the plants constituting California Rare Plant Rank 2B meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and are eligible for state listing. Impacts to these species or their habitat must be analyzed during preparation of environmental documents relating to CEQA, or those considered to be functionally equivalent to CEQA, as they meet the definition of Rare or Endangered under CEQA Guidelines **§**15125 (c) and/or **§**15380.

California Rare Plant Rank 3: Plants About Which More Information is Needed - A Review List

Plants with a California Rare Plant Rank of 3 are united by one common theme - we lack the necessary information to assign them to one of the other ranks or to reject them. Nearly all of the plants constituting California Rare Plant Rank 3 are taxonomically problematic. For each California Rare Plant Rank 3 plant we have provided the known information and indicated in the "Notes" section of the CNPS *Inventory* record where assistance is needed. Data regarding distribution, endangerment, ecology, and taxonomic validity are welcomed and can be submitted by emailing the Rare Plant Program at rareplants@cnps.org.

Many of the plants constituting California Rare Plant Rank 3 meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and are eligible for state listing. Impacts to these species or their habitat should be analyzed during preparation of environmental documents relating to CEQA, or those considered to be functionally equivalent to CEQA, as they may meet the definition of Rare or Endangered under CEQA Guidelines **§**15125 (c) and/or **§**15380.

California Rare Plant Rank 4: Plants of Limited Distribution - A Watch List

Plants with a California Rare Plant Rank of 4 are of limited distribution or infrequent throughout a broader area in California, and their status should be monitored regularly. Should the degree of endangerment or rarity of a California Rare Plant Rank 4 plant change, we will transfer it to a more appropriate rank.

Some of the plants constituting California Rare Plant Rank 4 meet the definitions of the California Endangered Species Act of the California Department of Fish and Game Code, and few, if any, are eligible for state listing. Nevertheless, many of them are significant locally, and we strongly recommend that California Rare Plant Rank 4 plants be evaluated for impact significance during preparation of environmental documents relating to CEQA, or those considered to be functionally equivalent to CEQA, based on CEQA Guidelines §15125 (c) and/or §15380. This may be particularly appropriate for:

- The type locality of a California Rare Plant Rank 4 plant,
- Populations at the periphery of a species' range,
- Areas where the taxon is especially uncommon,
- Areas where the taxon has sustained heavy losses, or
- Populations exhibiting unusual morphology or occurring on unusual substrates.

Threat Ranks

- 0.1-Seriously threatened in California (over 80% of occurrences threatened / high degree and immediacy of threat)
- 0.2-Moderately threatened in California (20-80% occurrences threatened / moderate degree and immediacy of threat)
- 0.3-Not very threatened in California (less than 20% of occurrences threatened / low degree and immediacy of threat or no current threats known)

Notes:

1. The above Threat Rank guidelines only represent a starting point in the assessment of threat level. Other factors, such as habitat vulnerability and specificity, distribution, and condition of occurrences, are also considered in setting the Threat Rank.
2. Many of the Threat Ranks have not been reassessed since the time they were first designated after implementation of the Rare Plant Status Review Process, and therefore may not represent the current level of threats associated with a given taxon.
3. The Threat Ranks do not designate a change of environmental protections. For instance a CRPR 1B.3 plant has the same environmental protections as a CRPR 1B.1 plant, and it is mandatory that both be fully considered during preparation of environmental documents relating to CEQA.

State and Federal Status

For each taxon with official status under the California Endangered Species Act (CESA), the Federal Endangered Species Act (FESA), and/or the Native Plant Protection Act (NPPA), the plant's status is presented. Our definitions conform to those found in California state law and federal regulations.

CNDDB ELEMENT RANKING[3]

Global Ranking

The *global rank* (G-rank) is a reflection of the overall status of an element throughout its global range. **Both Global and State ranks represent a letter+number score that reflects a combination of Rarity, Threat and Trend factors, with weighting being heavier on Rarity than the other two.**

Species or Natural Community Level

- **G1** = **Critically Imperiled** — At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
- **G2** = **Imperiled** — At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.

- **G3** = **Vulnerable** — At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
- **G4** = **Apparently Secure** — Uncommon but not rare; some cause for long-term concern due to declines or other factors.
- **G5** = **Demonstrably Secure** — Common; widespread and abundant.

Subspecies Level

Subspecies receive a **T-rank** attached to the G-rank. With the subspecies, the G-rank reflects the condition of the entire species, whereas the T-rank reflects the global situation of just the subspecies or variety. For example: *Chorizanthe robusta* var. *hartwegii*. This plant is ranked G2T1. The G-rank refers to the whole species range i.e., *Chorizanthe robusta.* The T-rank refers only to the global condition of var. *hartwegii*.

State Ranking

The *state rank* (S-rank) is assigned much the same way as the global rank, but state ranks refer to the imperilment status only within California's state boundaries.

- **S1** = **Critically Imperiled** — Critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
- **S2** = **Imperiled** — Imperiled in the state because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
- **S3** = **Vulnerable** — Vulnerable in the state due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
- **S4** = **Apparently Secure** — Uncommon but not rare; some cause for long-term concern due to declines or other factors.
- **S5** = **Secure** — Common, widespread, and abundant in the state.

Notes:

- Other considerations used when ranking a species or natural community include the pattern of distribution of the element on the landscape, fragmentation of the population/stands, and historical extent as compared to its modern range. It is important to take a **bird's eye or aerial view** when ranking sensitive elements rather than simply counting element occurrences.
- Uncertainty about the rank of an element is expressed in two major ways:
  - By expressing the ranks as a **range** of values: e.g., S2S3 means the rank is somewhere between S2 and S3.
  - By adding a ? to the rank: e.g., S2? This represents more certainty than S2S3, but less certainty than S2.
- Other symbols:
  - GH - All sites are **historical**; the element has not been seen for at least 20 years, but suitable habitat still exists (SH = All California sites are historical).
  - GX - All sites are **extirpated**; this element is extinct in the wild (SX = All California sites are extirpated).
  - GXC - Extinct in the wild; exists in cultivation.
  - G1Q - The element is very rare, but there are **taxonomic questions** associated with it.
  - T - Rank applies to a subspecies or variety.

Occurrence Data from DFG California Natural Diversity Database[2]

Element Occurrence (EO)

- **Element:** A plant, animal, or natural community tracked by the natural heritage program.
- **Occurrence:** The specific location(s) where an element is known to occur.

Definition of plant EOs in California: A population or group of populations found within 0.25 miles and not separated by significant habitat discontinuities.

Total # of Known Element Occurrences / Occurrence Count

The current number of occurrences for a particular element.

Element Occurrence Ranks

An element's *Occurrence Rank* is a ranking of the quality of the habitat and the condition of the population at that location. The possible values for Occurrence Rank are:

- **A** - Excellent
- **B** - Good
- **C** - Fair
- **D** - Poor
- **X** - None (extirpated or possibly extirpated element occurrences)
- **U** - Unknown

Population Status

Displays number of element occurrences that have been seen and/or not seen within the past 20 years. Element occurrences that have not been seen within the past 20 years are considered historic.

Presence

Presence refers to the condition of the occurrence at the site when it was last observed. The possible values for Presence are:

- **Presumed Extant:** The most common entry. An occurrence is presumed to still be in existence until evidence to the contrary is received by the CNDDB.
- **Possibly Extirpated:** Evidence of habitat destruction or population extirpation has been received by the CNDDB for this site, but questions remain as to whether the element still exists.
- **Extirpated:** Only used when the element has been searched for but not seen for many years or when the habitat is destroyed at this site.

Biology

Life Form

A brief description of plant duration and life form. The information is primarily developed from published and unpublished literature and from herbarium material. Our simplified classification system is as follows:

Duration:

- **Annual**: Grows from seed and reproduce within a single year.
- **Perennial**: Lives more than one year.
  (Annual/Perennials are variable depending on environment and conditions.)

Growth Form:

- **Herbs**: Plants that are herbaceous and lack above-ground woody tissue.
  - **Bulbiferous herb**: Plants have fleshy underground storage organs typically derived from scale leaves (this category includes cormiferous and other similar plants in which storage organs have other origins).
  - **Rhizomatous herb**: Plants have underground stems (rhizomes), typically bearing shoots which develop into new plants.
  - **Stoloniferous herb:** Plants have above-ground runners (stolons) which typically root and produce new plants.

- **Shrubs:** Smaller woody perennials that retain most of their above-ground woody tissue and are typically many-stemmed.
  - **Leaf succulents:** Succulents with thick, fleshy leaves.
  - **Stem succulents:** Succulents with thick, fleshy stems and reduced or absent leaves.
- **Trees:** Larger woody perennials that retain all of their above-ground wood tissue and are typically single-stemmed.
- **Vines:** Twining woody perennials requiring external support for growth.
- **Mosses:** Small green plants (one of three groups of bryophytes) with structures that resemble miniature leaves and stems. The leaves generally have a midrib called a costa. The sporophyte (the spore-bearing structure) is persistent for weeks.
- **Liverworts:** Small green plants (one of three groups of bryophytes). There are both leafy and thalloid types - leafy liverworts lack a midrib on the leaves, while thalloid liverworts have no leaves. The sporophyte is short-lived.
- **Leaf Condition (for shrubs, trees, vines only):**
  - **Deciduous**: Plants shed their leaves for part of the year.
  - **Evergreen:** Plants retain their leaves for an entire year.
- **Special Habitat**:
  - **Aquatic:** Plants are submerged or floating on the water surface.
  - **Emergent:** Plants are rooted in water but bear some foliage out of the water.
- **Mode of Nutrition**:
  - **Achlorophyllous:** Plants lack chlorophyll and live on existing organic matter in the soil.
  - **Hemiparasitic:** Plants are connected to host plants and derive energy, water, and minerals from them, but also maintain their own functional root systems or photosynthetic surfaces.
  - **Parasitic:** Plants are connected to host plants and rely solely on them for energy, water, and nutritional requirements.
  - **Carnivorous:** Plants trap insects and other small animals and derive nourishment from them.

As in most classifications, some of the above distinctions are somewhat arbitrary, particularly the divisions between growth forms. Furthermore, plant growth form can vary depending on geography and local environmental conditions. Perennials that are often referred to as either suffrutescent herbs or subshrubs present special difficulties. Generally, if these plants die back seasonally to the ground or to a small crown of woody tissue we classify them as herbs, and if they retain much or all of their woody above-ground tissue we call them shrubs.

Blooming Period

The month(s) when each rare plant is typically in bloom. For ferns and other spore-bearing plants, we give the months when spores are released and spore-bearing structures such as sori are typically present on the plant. We do not included any comparable information for gymnosperms and nonvascular taxa.
Note: Months in parentheses are uncommon.

Habitats

One or more habitats in which a rare, threatened, or endangered plant is typically found. This information is compiled from field survey forms, unpublished reports, original descriptions, floras, and herbarium material. Note that for habitats which typically occur within a broader matrix of another habitat, we usually list both. For example, a rare plant from Meadows and Seeps occurring in a matrix of Upper Montane Coniferous Forest would typically have its habitat presented as "Meadows and Seeps, Upper Montane Coniferous Forest."

Habitats follow brief characterizations outlined by Robert F. Holland and John O. Sawyer, Jr. and are presented in taxonomic rather than alphabetical order. Please refer to Holland (1986)[5] for a more complete discussion of the types and their classification.

Habitats:

- **Coastal Dunes:** Herbs or shrubs on coastal sand deposits from Del Norte to San Diego counties. Cover usually low near the beach, increasing with distance from salt spray and blowing sand.
- **Desert Dunes:** Sand accumulations east of the Pacific Crest from Modoc to Imperial counties. Vegetation on desert dunes varies considerably. Active dunes usually support only sparse herbs and grasses, but partially stabilized or stabilized dunes often will support shrubs, including mesquite and creosote bush.

- **Inland Dunes:** Mostly herbs, although shrubs may be locally important. Sand accumulations in and around the Great Valley.
- **Coastal Bluff Scrub:** Dense shrubs, prostrate to 1-2 meters tall. Typically on fairly steep, rocky sites exposed to considerable wind and salt spray because of proximity to the ocean. Many plants succulent, especially to the south. Found from Del Norte to San Diego counties.
- **Coastal Scrub:** Dense shrubs 0.5 to 2 meters tall with scattered grassy openings. Many plants dormant, even deciduous, during periods of water stress. Most sites have shallow rocky soils, frequently with a southern or western exposure. Many taxa adapted to fire by stump sprouting or high seed production.
- **Sonoran Desert Scrub:** Widely scattered creosote bushes with the considerable space between them sometimes occupied by ephemeral, colorful shows of annuals following particularly wet winters. Succulents and microphyllous trees conspicuous, especially in rocky environments. The part of Munz's (1959)[7] "Creosote bush scrub" found roughly south of the San Bernardino / Riverside county line.
- **Mojavean Desert Scrub:** Widely scattered creosote bushes with the considerable space between them sometimes occupied by ephemeral, colorful shows of annuals following particularly wet winters. At elevations of 600 meters or higher, succulents or microphyllous trees lacking. This habitat type constitutes most of Munz's (1959)[7] "Creosote bush scrub" found north of the San Bernardino / Riverside county line.
- **Great Basin Scrub:** Shrubs, ranging in height from very short, <20 centimeters, on very cold sites or shallow soils to 1 or 2 meters tall on warmer sites where soils are deeper. Perennial grasses occupy much of the space between shrubs. Found on the Modoc Plateau, high Cascade Range, Warner Mountains, High Sierra Nevada, and North Coast Ranges.
- **Chenopod Scrub:** Usually gray, intricately branched, microphyllous shrubs most commonly on fine-textured, alkaline and/or saline soils in areas of impeded drainage. Diversity usually low to monotonous. Saltbushes and greasewood frequently dominate. This vegetation occurs from Modoc County south to Mexico, including parts of the Great Valley and Inner South Coast Ranges.
- **Chaparral:** Impenetrably dense, evergreen, leathery-leaved shrubs that are active in winter, dormant in summer, and adapted to frequent fires either through resprouting or seed carry-over. There is a characteristic florula of fire-following annuals and short-lived perennials. Mature stands may exceed 3-4 meters in height. It occurs on diverse substrates, many of which support distinctive suites of edaphic indicators. Chaparral may be successional to conifer forests or oak woodlands, as tree seedlings can be found beneath the shrub canopies.
- **Coastal Prairie:** Dense, fairly tall (<1 meter) perennial sod- and tussock-forming grasses and grass-like herbs. They occur in two distinct settings: sandy marine terraces within the zone of coastal fog (usually <350 meters elevation, within a matrix of Northern Coastal Scrub), or on fine-textured soils of ridgetops beyond coastal fogs (usually >750 meters, within a matrix of Mixed Evergreen or North Coastal Conifer Forests). Intermittent from the Santa Cruz area north to southern Oregon.
- **Great Basin Grassland:** Perennial sod-forming and bunch grasses. Presumed to have once been widespread on the Modoc Plateau and northeastern California. Currently represented as scattered, mostly small, islands in areas where grazing pressure has been low and fire frequencies higher than surrounding scrubs. Both upland and bottom-land forms occur.
- **Valley and Foothill Grassland:** Introduced, annual Mediterranean grasses and native herbs. On most sites the native bunch grass species, such as needle grass, have been largely or entirely supplanted by introductions. Stands rich in natives usually found on unusual substrates, such as serpentinite or somewhat alkaline soils.
- **Vernal Pools:** Seasonal amphibious environments dominated by annual herbs and grasses adapted to germination and early growth under water. Spring desiccation triggers flowering and fruit set, resulting in colorful concentric bands around the drying pools.
- **Meadows and Seeps:** More or less dense grasses, sedges, and herbs that thrive, at least seasonally, under moist or saturated conditions. They occur from sea level to treeline and on many different substrates. They may be surrounded by grasslands, forests, or shrublands.
- **Playas:** Non-vascular plants and sparse, gray shrubs on poorly drained soils with usually high salinity and/or alkalinity, due to evaporation of water from closed basins. Found from the Modoc Plateau to Sonoran Desert and in the San Joaquin Valley.
- **Pebble or Pavement Plain:** Herb- and grass-dominated openings of low cover, dominated by several cushion-forming plants endemic to dense, clay soils armored by a lag gravel of quartzite pebbles. Many of the dominant taxa are themselves rare plants. Found only in the San Bernardino Mountains.
- **Bogs and Fens:** Wetlands, typically occupying sites sub-irrigated by cold, frequently acidic, water. Plant growth dense and low growing, dominated by perennials herbs or low shrubs. Saturated soils frequently allow substantial accumulations of "peat." From the Klamath Ranges to North Coast Ranges, along the North Coast and in the northern Sierra Nevada.
- **Marshes and Swamps:** Emergent, suffrutescent herbs adapted to seasonally or permanently saturated soils. These include salt, brackish, alkali, and fresh water marshes, as well as swamps, with their woody dominants and hydrophytic

herbs. Found throughout California.

- **Riparian Forest:** Broadleaved, winter deciduous trees, forming closed canopies, associated with low- to mid-elevation perennial and intermittent streams. Most stands even-aged, reflecting their flood-mediated, episodic reproduction. These habitats can be found in every county and climate in California.
- **Riparian Woodland:** Broadleaved, winter deciduous trees with open canopies associated with low- to mid-elevation streams. Most stands even-aged, reflecting their flood-controlled, episodic reproduction. This type tends to occupy more intermittent streams, often with cobbly or bouldery bedloads.
- **Riparian Scrub:** Streamside thickets dominated by one or more willows, as well as by other fast-growing shrubs and vines. Most plants recolonize following flood disturbance.
- **Cismontane Woodland:** Trees deciduous, evergreen, or both, with open canopies. Broadleaved trees, especially oaks, dominate, although conifers may be present in or emergent through the canopy. Understories may be open and herbaceous or closed and shrubby. This type occurs on a variety of sites below the conifer forests in Mediterranean California.
- **Pinyon and Juniper Woodland:** Open stands of round-topped conifers to 5 meters. Understories frequently comprised of shrubs and herbs seen in adjacent stands lacking trees. They often form broad ecotones between higher elevation forests and lower elevation scrublands or grasslands.
- **Joshua Tree Woodland:** Joshua trees with open canopies are usually the only arborescent species present. Shrubstories typically are diverse mixtures of microphyllous, evergreen shrubs, semi-deciduous shrubs, semi-succulents, and succulents.
- **Sonoran Thorn Woodland:** Succulents, microphyllous herbs and shrubs, especially of rocky environments. Tree-like plants the visual dominant.
- **Broadleaved Upland Forest:** Stands of evergreen or deciduous, broadleaved trees 5 meters or more tall, forming closed canopies. Many, but not all, with very poorly developed understories. Several are seral to montane conifer forests. It includes the "mixed evergreen forest" of the Coast Ranges.
- **North Coast Coniferous Forest:** Needle-leaved evergreen trees in usually quite dense stands that may attain impressive heights. Usually on well-drained, moist sites within the reach of summer fogs, but not experiencing much winter snow. This type occurs in the wetter parts of the North Coast Ranges.
- **Closed-cone Coniferous Forest:** Dense, even-aged stands dominated by serotinous-coned conifers. Most stands are even-aged due to fire establishment. Usually associated with sterile, rocky soils, strong and steady winds, and impaired drainage. Many open stands have understories composed of chaparral or coastal scrub species from surrounding areas. Found in most areas, except for the Great Valley or deserts.
- **Lower Montane Coniferous Forest:** Open to dense stands of conifers found at lower and middle elevations in the mountains. Broadleaved trees may be present in the understory. Shrubstories may be dense assemblages of chaparral species, especially in seral stands. The upper limit of lower montane coniferous forests more or less coincides with the elevation of maximum annual precipitation.
- **Upper Montane Coniferous Forest:** Open to dense conifer forests, found at high elevations in the mountains. Trees tend to be somewhat shorter than at lower elevations. Shrubstories tend to be open, drawn from adjacent montane chaparral species, or lacking. Above the elevation of maximum precipitation, with growing seasons curtailed by winter snow accumulations.
- **Subalpine Coniferous Forest:** Conifer forests and associated clearings of highest elevations of tree establishment. This type occurs in areas where substantial snowpack accumulation and cold temperatures limit the growing season to three months or less.
- **Alpine Boulder and Rock Field:** Fell-fields, talus slopes, and meadows found above forest line. Favorable sites may develop continuous turf, but in most areas plants are tucked between large nurse rocks that provide protection from harsh winter conditions.
- **Alpine Dwarf Scrub:** Compact, woody subshrubs above forest line, adapted to short growing seasons resulting from snow accumulation or harsh winter winds.

Habitat Modifiers

Descriptors that denote substrate type, hydrological information, etc., are often used to modify habitat types as follows:

- "**(descriptor)**" pertains only to the habitat type immediately preceding
- "**descriptor**" prior to habitat types pertains to *all* habitats

Typical Modifiers

sandy	serpentinite	burned areas	bajadas
gravelly	granitic	disturbed areas	lake margins
rocky	carbonate	roadsides	streambanks
scree	gabbroic	openings	
talus	volcanic	edges	freshwater (used for Marshes and Swamps)
	metamorphic	mesic	coastal salt (used for Marshes and Swamps)
alkaline	clay	vernally mesic	maritime (used for Chaparral)
acidic	pumice	seeps	coastal
	loam		

Distribution

The distribution of the taxon is described by county or island within California, together with other states and countries where we know the plant to exist. We record only natural occurrences of rare plants, or occurrences that have been reestablished within the species' historic range as part of an approved recovery plan. For example, although both Northern California black walnut (*Juglans hindsii*) and Monterey pine (*Pinus radiata*) are widely planted within the state, we track only the few natural occurrences of these taxa. When we indicate that a particular plant occurs in a particular county, we are making a positive statement that is based upon specimens, photographs, the literature, or field observations. In no way does this imply that a plant does not occur in other counties in California or in other states. Our understanding of plant distribution constantly improves, and new localities for rare plants are discovered often in unpredicted circumstances.

The following symbols are used as modifiers preceding counties, quads, and/or states to express extirpation and/or uncertainty:

- * Presumed extirpated
- ? Uncertain about distribution or identity
- ?* Uncertain about distribution, but presumed extirpated if once present
- (?) Occurrence confirmed, but possibly extirpated

Counties and Islands

Three letter codes have been attributed for each county and island within California to maintain and manage swift data control of the *Inventory*. In turn, these codes are used as abbreviations in the "Notes" section on the plant detail page for some taxa.

County and Island Codes:

ALA Alameda	**MEN** Mendocino	**SIE** Sierra
ALP Alpine	**MER** Merced	**SIS** Siskiyou
AMA Amador	**MOD** Modoc	**SJQ** San Joaquin
ANA Anacapa Isl.	**MNO** Mono	**SLO** San Luis Obispo
BUT Butte	**MNT** Monterey	**SMI** San Miguel Isl.
CAL Calaveras	**NAP** Napa	**SMT** San Mateo
CCA Contra Costa	**NEV** Nevada	**SNI** San Nicolas Isl.
COL Colusa	**ORA** Orange	**SOL** Solano
DNT Del Norte	**PLA** Placer	**SON** Sonoma
ELD El Dorado	**PLU** Plumas	**SRO** Santa Rosa Isl.
FAR Farallon Isl.	**RIV** Riverside	**STA** Stanislaus
FRE Fresno	**SAC** Sacramento	**SUT** Sutter
GLE Glenn	**SBA** Santa Barbara	**TEH** Tehama
HUM Humboldt	**SBD** San Bernardino	**TRI** Trinity
IMP Imperial	**SBR** Santa Barbara Isl.	**TUL** Tulare
INY Inyo	**SBT** San Benito	**TUO** Tuolumne
KNG Kings	**SCL** Santa Clara	**VEN** Ventura
KRN Kern	**SCM** San Clemente Isl.	**YOL** Yolo
LAK Lake	**SCT** Santa Catalina Isl.	**YUB** Yuba
LAS Lassen	**SCR** Santa Cruz	
LAX Los Angeles	**SCZ** Santa Cruz Isl.	**BA** Baja California
MAD Madera	**SDG** San Diego	**GU** Isla Guadalupe, Baja

MPA Mariposa	**SFO** San Francisco	**SA** South America
MRN Marin	**SHA** Shasta	**SO** Sonora, Mexico

Quadrangles

To provide more detailed location information, we cite the U.S. Geological Survey (USGS) 7.5 minute quadrangle (quad) map for all plants on CNPS Lists 1, 2, and 3, as well as some plants on List 4 (please see warning about quad maps for List 4's below). We employ a modified version of the quad numbering system previously used by the California Department of Water Resources. Please follow this link to translate this system's quad numbers into USGS topographic map names or vice versa. In those few cases where a quad is listed without a letter following the number, this indicates that our occurrence data are too vague to pinpoint its location on a 7.5 minute quadrangle. As with counties, this is positive siting information - when we indicate that a plant has been reported from an area on a topographic quad, it is based on hard data. In no way does this imply that a plant does not occur on a topographic quad we have not listed; rather, it may be there but botanists have yet to find it. As with distribution, quads are also often modified with the symbols "*" and "?", which respectively express extirpation and uncertainty (see above).

Quad data is not available for all List 3 and 4 plants. For those that do contain this data, it has not been quality controlled and is potentially incomplete, inaccurate, and/or out of date. Please use caution when referencing this information. We are currently working hard to maintain this data and hope to provide accurate and up to date information in the near future.

A complete list of California USGS quads is available here. Alternatively, an abbreviated index of only quads occupied with taxa included in the *Inventory* is available here.

Elevation

An elevational range is provided for each taxon in meters. The stated range is for the California portion of a plant's range only (if the taxon also occurs outside the state). These elevational range data are accumulated from literature, herbarium specimens, and field survey information.

Notes

Many entries include additional notes on distribution, endangerment, relationship to names in The Jepson Manual, or important literature citations. We again include information about legal status and endangerment in neighboring states in the notes; official state designations are specifically indicated as such and capitalized, as in "State-listed as Endangered in OR". We make a special effort to indicate missing information about distribution, endangerment, or taxonomy for each entry, in the hope that knowledgeable users will fill in the gaps.

Abbreviations that are commonly used in the notes include:

ACEC	Area of Critical Environmental Concern	**NA**	North America
AFB	Air Force Base	**NF**	National Forest
BA	Botanical Area	**NM**	National Monument
BLM	Bureau of Land Management	**NP**	National Park
CalTrans	California Department of Transportation	**NS**	National Seashore
Cyn.	Canyon	**Pk.**	Peak
DFG	California Department of Fish and Wildlife	**Pt.**	Point
DOD	United States Department of Defense	**RNA**	Research Natural Area
ER	Ecological Reserve	**SP**	State Park
Ft.	Fort	**SR**	State Reserve
HCP	Habitat Conservation Plan	**TNC**	The Nature Conservancy
Mt.	Mount	**USFS**	United States Forest Service
Mtn.	Mountain	**USFWS**	United States Fish and Wildlife Service
Mtns.	Mountains	**WA**	Wildlife Area

Threats: Includes information on *significant* threats to the plant over its range in California. Typical threats provided in the notes section include, but are not limited to the following:

development	recreational activities	military activities
urbanization	foot traffic (i.e. from people)	Border Patrol activities
agriculture		
logging	energy development	alteration of fire regimes
	pipeline construction	fire suppression
vehicles		frequent wildfires
horticultural collecting	mining	
illegal dumping	sand mining	competition
	gravel mining	non-native plants
road construction	carbonate mining	introgression with...
road maintenance	limestone mining	hybridization with...
road widening		
	flood control projects	meadow succession
grazing	hydrological alterations	erosion
overgrazing	inundation	habitat loss
innappropriate grazing	water diversions	habitat alteration
trampling	waterway channelization	habitat disturbance
feral herbivores	groundwater pumping	
feral pigs	flood control	
feral goats		

Literature Cited

1. ^ Abrams, L.R. 1923-1960. An Illustrated Flora of the Pacific States, Washington, Oregon and California. Vol. 4 by R. Ferris. Stanford University Press. Stanford, CA. 4 vols.
2. ^ California Department of Fish and Wildlife, Natural Diversity Database. 2010. Metadata Description of CNDDB fields. RareFind 4 internet application. Accessed November 5, 2010.
3. ^ California Department of Fish and Wildlife, Natural Diversity Database. 2010. Special vascular plants, bryophytes, and lichens list. Quarterly publication, October 2010. 85 pp. Available online at: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPPlants.pdf.
4. ^ Hickman, J.C., ed. 1993. The Jepson Manual: Higher Plants of California. University of California Press. Berkeley, CA. 1400 pp.
5. ^ Holland, R.F. 1986. Preliminary Descriptions of the Terrestrial Natural Communities of California. Nongame-Heritage Program, California Department of Fish and Wildlife. Sacramento, CA. 156 pp.
6. ^ Kartesz, J.T., and J.W. Thieret. 1991. Common names for vascular plants: Guidelines for use and application. *Sida* 14(3):421-434.
7. ^ Munz, P.A. 1959. A California Flora. In collaboration with D.D. Keck. University of California Press. Berkeley, CA. 1681 pp.
8. ^ Munz, P.A. 1968. Supplement to a California Flora. University of California Press. Berkeley, CA. 224 pp.
9. ^ Munz, P.A. 1974. A Flora of Southern California. University of California Press. Berkeley, CA. 1086 pp.
10. ^ Shevock, James R. 1993. How plants get their names and why names change. *Fremontia* 21(1):19-24.
11. ^ Skinner, Mark W. and Barbara Ertter. 1993. Whither rare plants in The Jepson Manual? *Fremontia* 21(3):23-27.

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EXHIBIT 4

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Noise Levels Associated with Urban Land Use

Gavin King, Marek Roland-Mieszkowski, Timothy Jason, and Daniel G. Rainham

ABSTRACT *Recent trends towards the intensification of urban development to increase urban densities and avoid sprawl should be accompanied by research into the potential for related health impacts from environmental exposure. The objective of the current study was to examine the effect of the built environment and land use on levels of environmental noise. Two different study areas were selected using a combination of small area census geography, land use information, air photography, and ground-truthing. The first study area represented residential land use and consisted of two- to three-story single-family homes. The second study area was characteristic of mixed-use urban planning with apartment buildings as well as commercial and institutional development. Study areas were subdivided into six grids, and a location was randomly selected within each grid for noise monitoring. Each location was sampled four times over a 24-h day, resulting in a total of 24 samples for each of the two areas. Results showed significant variability in noise within study areas and significantly higher levels of environmental noise in the mixed-use area. Both study areas exceeded recommended noise limits when evaluated against World Health Organization guidelines and yielded average noise events values in the moderate to serious annoyance range with the potential to obscure normal conversation and cause sleep disturbance.*

KEYWORDS *Noise, Land use, Urban, Geographic information systems, Sound level meter*

INTRODUCTION

The human environment has become increasingly shaped by urbanization and the built environment, which comprises the physical infrastructure arising from urban development as well as managed green space such as urban forests, parks, and sport fields.[1] Indeed, more than half of the global population and over 80 % of North Americans now reside in urban areas.[2] The built environment is now attracting the attention of public and environmental health researchers, as its inherent quality, characteristics, and spatial orientation (i.e., urban sprawl) have been linked both positively (e.g., parks, trails) and negatively (obesity, injuries, stress) to a variety of health outcomes.[3,4] Increasing urbanization has been linked to a rise in the prevalence of health disparities, as well as a growing culture of sedentary living,

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contributing to the development of several chronic disease outcomes.[5] In efforts to improve urban conditions and enhance human well-being, municipal planning groups have developed and promoted several initiatives, including mixed-use development strategies. A potential consequence of these strategies is an increase in environmental noise levels.

Environmental noise is an increasingly common feature of urban areas that can be described as an unwanted or undesirable sound within non-occupational settings. Road, rail, and air traffic sources account for the majority of noise in urban and surrounding areas.[6] Additional sources of noise include industrial/commercial enterprise, construction projects, and such familiar domestic sources as pets and radios/stereos. Municipal planning strategies emphasizing increases in urban development densities, mixed-uses, as well as a continuation of automobile-centered traffic planning policies may lead to an increase in population level exposure to traffic and related urban environmental noise. At present, little is known regarding how noise levels may vary with forms of urban development and affect the health of a population.

Environmental noise has been linked to several non-auditory, biologically relevant health outcomes, including: increased levels of hypertension and high blood pressure,[7] lowered cognitive ability,[8] and an increased prevalence of cardiovascular disease.[9] Exposure to environmental noise from traffic-related sources is reportedly the most annoying of all urban pollution types,[10] interfering with enjoyment of daily activities and largely affecting sleep and rest patterns.[10–12] In a recent Canadian survey, 20–28 % of urban populations attributed noise from road traffic to disruptions during sleep, conversation, and communication tasks such as reading and writing.[13] Few studies have conducted field measurements to assess levels of environmental noise in Canadian cities; furthermore, it is still unknown whether recent trends towards the intensification of urban development will impact environmental noise levels and in turn population health.

Acceptable noise level guidelines have been developed by several agencies based on levels of annoyance, interference with communications, disturbance to sleep, and the potential to cause hearing impairments.[14,15] For example the US Environmental Protection Agency recommended a maximum indoor noise level of 45 dB(A)[*] and outdoor noise level of 55 dB to allow for intelligible communication.[16] Typically, values are derived for specific settings and time periods. Some agencies also provide guidelines according to land use and population density (e.g., Italian legislation in 1997). Recommended urban residential noise levels generally range from 45 to 55 dB depending on the time of day and location of measurement. For example, Australian Environmental Protection Authority noise guidelines state that noise levels in urban residential neighborhoods should not exceed 55 dB(A) during the day and 47 dB(A) at night (i.e., from 22:00 to 06:00). The maximum recommended noise levels generally increase in relation to the amount of commercial activity, which presents challenges for cities developing policies related to integrated residential and commercial land uses.

As with many urban centers in Canada and abroad, the Halifax Regional Municipality intends to intensify urban development by combining residential and

[*]Sound is measured by comparing the logarithm of a given sound to a reference sound pressure, and is expressed on a logarithmic decibel (dB) scale. The A-weighting [dB (A)] system was devised to adjust results in studies examining the impact of environmental noise on human hearing specifically.

commercial land-use types. The objective is to promote mixed-use neighborhoods with focused development in core areas. A number of reasons have been cited for this development strategy including the high costs of municipal services and rising costs of health care (e.g., obesity, transportation injuries) related to sprawl and associated increased automobile use.[17–19] Research into these issues is required not only to protect the health and well-being of urban inhabitants, but also to ensure that planning decisions are based on evidence that considers the potential health and environmental consequences of development. To date, few studies have examined how noise varies as a function of urban development.

The aim of this study was to assess and compare noise levels in two urban neighborhoods: one completely residential and comprised of mostly single and multi-family dwellings, and the other characteristic of mixed residential and commercial land uses. Ambient environmental noise was recorded, measured, and analyzed within defined spatial locales in order to determine the potential for cumulative exposure to the local population. This research is timely and potentially informative given current trends in urban development.

METHODS

For the purpose of this study, two neighborhoods were selected: one almost exclusively residential to represent traditional planning strategies and the other comprised of residential and commercial land uses to represent more modern planning strategies that emphasize mixed-use development in urban core areas. The boundaries of each neighborhood matched the smallest statistical boundaries developed for the dissemination of Canadian census data (see Figure 1). Area 1, the representative residential area, mostly contained single-family dwelling units up to 10 m in height with 653 residents and a population density of approximately 3,950 persons per square kilometer. Buildings in this area are generally free standing and constructed of wood, stone, and brick. Area 1 also included seven roads (total length = 3,506 m) that either border or are situated within the area. Area 2, representing mixed commercial and residential land uses, was larger in area yet housed a smaller population of 566 residents (1,836.5 persons per square kilometer). This area is bounded by several major roads and is generally oriented east to west. Area 2 contains commercial, institutional, and residential zones, with mostly concrete multi-story buildings. Sixteen roads traversed the area totaling 6,271 m in length.

Sampling Strategy

Study areas 1 and 2 were each divided by a grid into six identical cells. A geographic information system was used to randomly select one sample site location within each cell in the following manner. First, road network polygons were imported and a 4-m buffer polygon was inserted from the edge of the road. Second, a spatial random point generator, constrained to one point per grid cell within the buffer polygon, identified six sampling locations per study area. As a result, one randomly selected sample point per grid square was included in the analysis (Figure 1). Forty-five-minute noise recordings were randomly sampled during each of four distinct time periods from each of the six sampling locations per study area.

Environmental noise sampling methods vary considerably. For example, studies have used a sampling frequency of 15-min measurements every 2 h,[20] while others have employed continuous assessments.[21] Studies have measured noise levels during

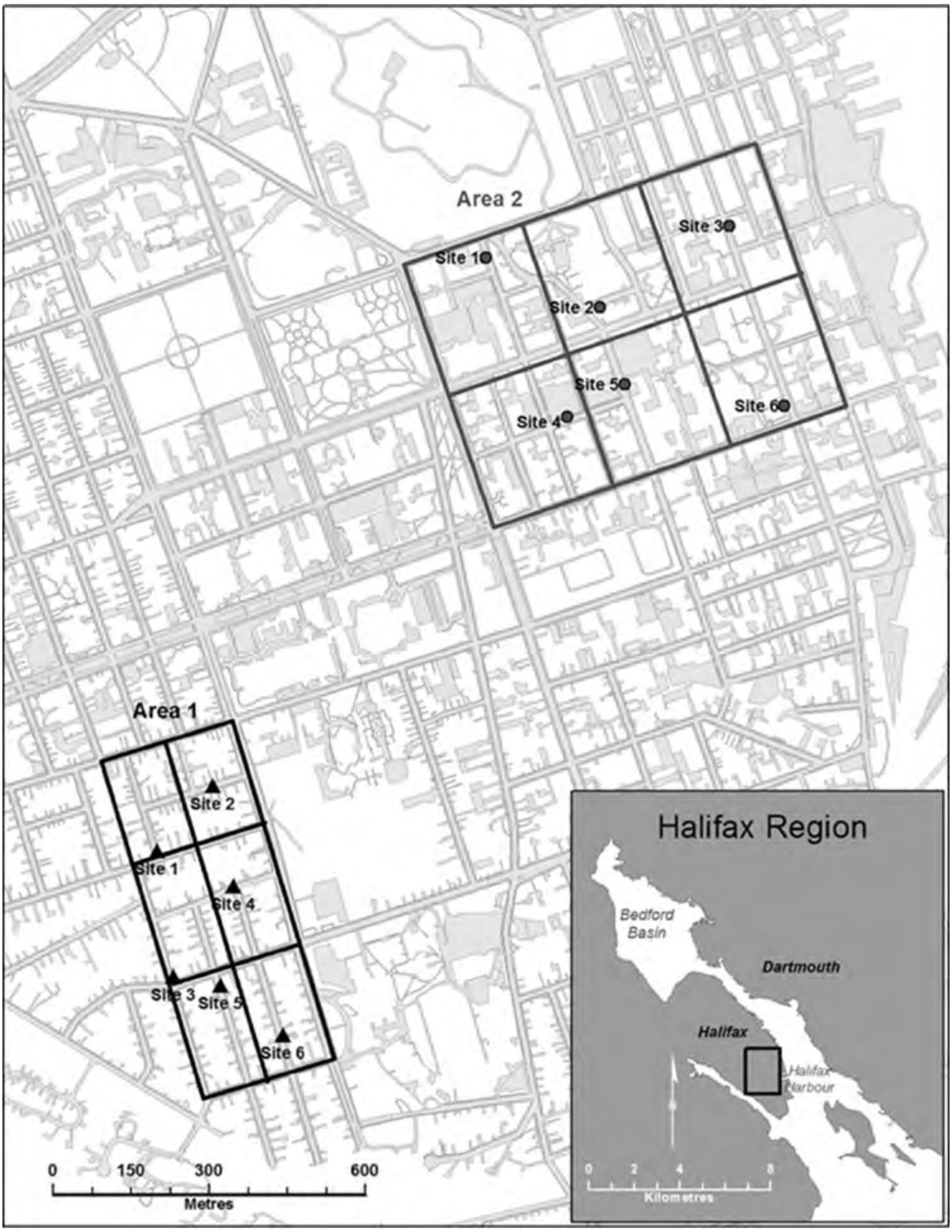

FIGURE 1. Study areas and sampling sites.

the day and at night,[22] while others have only considered measurements during the day.[23] In 2007, Ng and Tang adopted a three-period assessment in which a 24-h clock was divided into three periods (day, evening, and night) that differed slightly in their period start times and sample lengths.[24] For the purpose of the current study, we incorporated a modified version of the three-period assessment method with certain refinements, as discussed by Ng and Tang,[24] for improving statistical accuracy. Each sample location yielded 3 h of data distributed across four time periods (i.e., 45 min per sampling period for each location). Daytime periods were subdivided into morning (06:00–12:00 h) and afternoon (12:00–18:00 h) segments to enhance assessment quality. In addition, hours in the evening period (18:00–24:00 h) and the night period (24:00–06:00 h) were randomly sampled in order to capture the full daily spectrum of environmental noise production.

Data Collection

Noise data were collected using a Centre 322 Logging Sound Level Meter (SLM) and a Marantz PMD-660 Solid State Digital Recorder. The Centre SLM is an ANSI S1.4 Type 2 instrument with a 0.5″ electrets condenser microphone, frequency range of 31.5 Hz to 8 KHz, measuring level range of 30–130 dB, and capacity to weight frequencies to either the A or C scale. The Marantz PMD-660 Solid State Digital Recorder was connected to an external microphone that can record 4 h of data at frequencies of 44.1/48 KHz.

The SLM and sound recorder were mounted on a camera tripod and microphone stand at a height of 1.5 m, a distance of 0.5 m from the curb, and were oriented perpendicularly to the nearest road. The SLM logged noise using an average of 1 s measurements, while the digital sound recorder facilitated continuous recordings to qualitatively identify peak noise events. Recordings commenced at the top of each hour (e.g., 1:00, 2:00…); in addition, the particular time at which recordings commenced was randomly assigned to sample locations thereby ensuring that the full 6-h time period (i.e., day, afternoon, evening, and night) was sampled. No data collection occurred on days ($n=2$) with rain, snow, or high winds, because these elements can both damage equipment and decrease the accuracy of measurements. Preliminary analysis of noise data from a related and, as of yet, unpublished study found that weather conditions, precipitation and wind in particular, had no influence on noise levels measured at a frequency of one measurement per hour. This conclusion was derived from comparing statistically noise levels measured during high wind or rain events (or both) with noise levels during times when weatherproofing of instrumentation would not be required.

Data Analysis

The SLM data included the minimum and maximum sound pressure level (SPL) averaged over 1 s, which resulted in 2,700 data points for each sampled time period and 10,800 data points for each grid sample area in a 24-h period. Basic noise descriptors were calculated. In addition, the equivalent continuous sound pressure level (L_{Aeq}) and day–evening–night composite whole-day rating level (L_{Rden}) were derived for the sample periods, grid sample areas, and study areas to identify variations in environmental noise over both space and time.

The two study areas were statistically evaluated and compared. First, each study area was examined individually to determine the spatial variation of environmental noise during each 6-h period and the full 24-h period. Noise levels associated with individual sample sites within each study area were compared statistically using a series of Kruskal–Wallis tests for non-parametric data. Then, the two primary study areas were compared statistically using the Mann–Whitney two-sample rank test.

L_{Aeq} values were compared with environmental noise exposure limits as dictated by Italian legislation (see Piccolo et al. 2005 for the exposure limits). In order to accomplish this, the study data were recalculated to correspond with the standardized time periods adopted by Italian legislation. This approach provided a means to determine levels of noise exposure with comparison to standards developed to prevent potential human health risk.

Calculation

Each study area yielded 18 h of data comprising 3 h per site (four time period samples of 45 min each). The A weighted equivalent continuous sound pressure level (L_{Aeq}) was calculated for each sample using the following formula:

$$L_{\mathrm{Aeq}} = \frac{10\left(\log \frac{1}{T}\right) \int P_A{}^2(t)}{p_o{}^2(dt)} \tag{1}$$

$P_A{}^2$ – The A-weighted instantaneous sound pressure at the running time t;
p_o – The standard reference sound 20 μPa

The resultant L_{Aeq} values were then adjusted according to the particular sampled time period (+5 dB for evening hours and +10 dB for night-time hours) using the formula indicated below:

$$L_{\mathrm{Req}j,Tn} = L_{\mathrm{Aeq}j,Tn} + K_j \tag{2}$$

K_j – Adjustment for the specified sample and time period;
$L_{Aeqj,Tn}$ – The actual L_{Aeq} value at the specified time period

Using the adjusted L_{Aeq} values, the day–evening–night rating levels were derived using the following formula:

$$L_{Rden} = 10\log\left[\frac{d}{24} \times 10^{\frac{LRd}{10}} + \frac{e}{24} \times 10^{\frac{LRe}{10}} + \frac{(24-d-e)}{24} \times 10^{\frac{LRn}{10}}\right] db \tag{3}$$

d – The number of daytime hours;
n – The number of night-time hours;
e – The number of evening hours;
L_{Rd} – The rating level for daytime hours including adjustments;
L_{Re} – The rating level for evening hours including adjustments;
L_{Rn} – The rating level for night-time hours including adjustments

RESULTS

Area 1

The distribution of sound in area 1 was skewed to the right and somewhat peaked with an overall mean sound level of 48.1 dB(A) (SD = 7.6) and substantial variation among individual sites (Table 1). Maximum values for the individual sites ranged from 60.6 dB(A) at site 6 to 93.3 dB(A) at site 3, while minimum values ranged from 20.0 dB(A) at site 3 to 47.0 dB(A) at site 4. Site 3 evidenced the greatest range of sound with night recordings of 20.0 dB(A) to 93.3 dB(A). L_{A90} values (90th percentile), representing background noise in the area, ranged from a low of 38.2 dB (A) at site 3 to a high of 50.3 dB(A) at site 4. Site 3 yielded higher than average L_{A1} values (1st percentile), indicating high levels of road traffic near the sample points. Adjusted (Adj) L_{Aeq} values ranged from a low of 44.7 dB(A) at site 6 to a high of 76.8 dB(A) at site 3. A comparison of the four sample time periods across sites evidenced maximum SPLs between 71.3 dB(A) and 77.4 dB(A) and mean SPLs from a low of 44.0 dB(A) to a high of 51.5 dB(A) (Table 2). L_{A90} values for the four time periods ranged from a low of 41.6 dB(A) to a high of 45.4 dB(A), while Adj L_{Aeq} ($\bar{x} = 57.3$ dB(A)) values ranged from a low of 56.0 dB(A) to a high of 59.1 dB(A). Table 1 shows site 3 ($\bar{x} = 68.9$ dB(A)) and the night period ($\bar{x} = 59.1$ dB(A)) as having the highest overall Adj L_{Aeq} levels.

TABLE 1 Summary statistics for area 1

Site	Period	Start time	Max	Min	Mean	Percentiles L_{A1}	Percentiles L_{A90}	L_{Aeq}	Adj L_{Aeq}
1	1	07:00	73.0	40.1	44.2	60.0	41.8	48.5	48.5
	2	16:00	73.3	41.4	47.7	65.1	42.8	53.2	53.2
	3	18:00	66.6	25.8	43.9	61.8	39.5	49.2	54.2
	4	03:00	66.3	41.7	43.9	51.6	42.8	45.0	55.0
2	1	08:00	72.9	43.7	51.3	67.4	46.3	55.4	55.4
	2	12:00	75.4	40.9	48.0	63.7	43.3	53.0	53.0
	3	22:00	65.2	21	44.2	55.9	41.5	46.6	51.6
	4	01:00	66.3	38.8	40.3	49.2	39.4	42.0	52.0
3	1	09:00	90.0	42.3	61.4	80.3	48.0	69.1	69.1
	2	14:00	86.6	40.0	57.7	76.3	45.7	66.3	66.3
	3	23:00	81.4	37.0	43.1	72.1	38.2	58.6	63.6
	4	05:00	93.3	20.0	48.0	77.6	43.3	66.8	76.8
4	1	10:00	79.8	47.0	58.1	67.1	50.3	63.1	63.1
	2	15:00	77.5	23.0	49.0	56.7	43.0	54.8	54.8
	3	21:00	78.9	43.9	53.8	63.7	46.8	60.0	65.0
	4	24:00	77.4	39.9	45.8	55.0	41.3	52.9	62.9
5	1	11:00	72.7	41.6	50.8	66.6	43.9	55.4	55.4
	2	13:00	77.5	23.0	49.0	66.7	43.0	54.8	54.8
	3	19:00	73.9	37.8	48.4	65.0	40.5	54.2	59.2
	4	04:00	63.7	42.2	44.4	53.4	43.0	45.2	55.2
6	1	06:00	67.9	40.5	43.1	50.0	41.9	44.7	44.7
	2	17:00	73.8	42.6	49.8	66.5	45.6	54.6	54.6
	3	20:00	73.4	41.2	45.5	61.7	43.0	50.3	55.3
	4	02:00	60.6	38.3	41.7	51.5	40.2	42.7	52.7

As evident from Table 1, Adj L_{Aeq} values peaked at 05:00, 09:00, 14:00, and 23:00 (site 3), as well as at 21:00 and 00:00 (site 4). L_{Aeq} values mirrored this trend. The results suggest that the maximum values associated with these particular sites may have augmented the average noise level of the study area. The composite whole day rating for area 1 equaled 63.8 dB(A).

A significant difference in noise among individual sample sites in area 1 was observed, χ^2 (5, N=24)=16.2, p=0.01. Site 6 was associated with the lowest Adj L_{Aeq} levels in the area ($\bar{x} = 51.8$) yet produced a comparatively high number of outlier values throughout the day from elevated noise events. Site 3, which contributed the highest levels of environmental noise in area 1 ($\bar{x} = 68.9$), yielded a different data distribution pattern with fewer outlier points all of which occurred in the evening and night-time periods. A similar comparison across time periods failed to yield a significant difference, χ^2 (3, N=24)=0.55, p=0.91.

TABLE 2 Statistical values for area 1 by sample time period

	Max	Mean	L_{A1}	L_{A90}	L_{Aeq}	Adj L_{Aeq}
Morning	76.0	51.5	66.4	45.4	56.0	56.0
Afternoon	77.4	50.2	67.5	43.9	56.1	56.1
Evening	73.2	46.5	64.6	41.6	53.2	58.2
Night	71.3	44.0	57.8	41.7	49.1	59.1

Area 2

Data from area 2 yielded a similar distribution to area 1 with an overall mean of 56.6 dB(A). However, area 2 evidenced less variation in recorded sound values among individual sites and time periods (Table 3). Peak SPLs ranged from 69.7 dB (A) at site 2 to 90.3 dB(A) at site 6, while L_{A90} values ranged from a low of 44.0 dB (A) at site 6 to a high of 59.3 dB(A) at site 1. Adj L_{Aeq} values across sites ranged from a low of 55.4 dB(A) at site 4 to a high of 72.2 dB(A) at site 6. A comparison of the four sample time periods across sites yielded maximum SPLs between 77.2 dB(A) and 84.9 dB(A). L_{A90} values for the four time periods ranged from a low of 47.1 dB (A) to a high of 54.6 dB(A), while Adj L_{Aeq} values ranged from 61.8 dB(A) in the afternoon to 66.3 dB(A) at night (Table 4). The results indicate that area 2, the mixed use area, is associated with a more consistent level of environmental noise across sample sites. For example, L_{A90} values were highest recording in the afternoon at 54.6 dB(A), which varied little from the morning value of 53.1 dB (A), and then decreased through the evening to 47.1 dB(A) at night. Site 6 ($\bar{x} = 69.9$ dB(A)) and the night period ($\bar{x} = 66.3$ dB(A)) were associated with the highest overall Adj L_{Aeq} values (Table 3).

Table 3 displays L_{Aeq} and Adj L_{Aeq} values for selected sites over a 24-h period. As evident from this table, area 2 yielded Adj L_{Aeq} peaks at 01:00 (site 5), 03:00, 07:00,

TABLE 3 Summary statistics for area 2

						Percentiles			
Site	Period	Start time	Max	Min	Mean	L_{A1}	L_{A90}	L_{Aeq}	Adj L_{Aeq}
1	1	09:00	87.0	52.3	63.1	79.1	56.4	68.2	68.2
	2	12:00	88.3	55.4	65.1	75.9	59.3	68.1	68.1
	3	20:00	77.3	49.1	56.0	69.1	51.4	59.0	64.0
	4	02:00	79.4	42.3	50.0	65.3	45.9	55.8	65.8
2	1	08:00	89.0	46.7	58.3	75.1	52.2	65.0	65.0
	2	14:00	85.9	46.7	56.0	69.3	51.9	60.8	60.8
	3	23:00	77.8	48.9	53.4	67.3	50.2	56.7	61.7
	4	04:00	69.7	42.5	47.3	59.9	44.9	49.6	59.6
3	1	10:00	86.8	54.5	60.8	77.0	56.2	66.0	66.0
	2	15:00	85.2	54.3	60.3	71.6	56.6	62.7	62.7
	3	18:00	83.3	54.1	60.4	72.5	55.9	63.5	68.5
	4	05:00	75.1	49.7	54.0	67.5	51.5	56.4	66.4
4	1	11:00	72.7	45.4	52.6	65.9	49.0	55.4	55.4
	2	13:00	83.4	47.3	53.7	67.7	50.0	58.5	58.5
	3	22:00	75.1	28.6	50.4	66.0	47.2	54.1	59.1
	4	24:00	71.9	45.7	49.7	62.9	47.3	52.4	62.4
5	1	06:00	77.3	47.4	54.0	70.1	49.0	58.9	58.9
	2	16:00	86.0	23.7	60.9	72.1	55.0	64.0	64.0
	3	19:00	77.6	48.5	57.7	72.3	51.7	62.1	67.1
	4	01:00	85.7	46.2	53.8	73.5	49.1	61.3	71.3
6	1	07:00	90.3	49.8	65.6	81.3	56.0	71.1	71.1
	2	17:00	80.4	49.6	63.1	75.7	54.9	66.7	66.7
	3	21:00	83.7	46.7	60.1	74.3	51.8	64.8	69.8
	4	03:00	81.4	23.6	51.7	75.6	44.0	62.2	72.2

TABLE 4 Statistical values for area 2 by sample time period

	Max	Mean	L_{A1}	L_{A90}	L_{Aeq}	Adj L_{Aeq}
Morning	83.9	59.1	74.8	53.1	64.1	64.1
Afternoon	84.9	59.9	72.1	54.6	61.8	61.8
Evening	79.1	56.3	70.3	51.4	60.0	65.0
Night	77.2	51.1	67.5	47.1	56.3	66.3

and 21:00 (site 6). L_{Aeq} values, although deflated, mirrored this trend. The composite whole day rating was calculated and produced a result of 65.0 dB(A).

A significant difference in noise among individual sample sites in area 2 was yielded, χ^2 (5, N=24)=14.51, p=0.01. However, a similar comparison across time periods failed to yield a significant difference, χ^2 (3, N=24)=1.29, p=0.73. Areas 2 and 1 sample sites exhibited similar patterns of variation among sample sites and time periods; still, area 2 evidenced fewer outlier points due to higher overall levels of environmental noise. Traffic events characteristic of area 2 were absorbed by ambient background noise and therefore did not produce significant increases in sound. In contrast, sample sites associated with less road traffic and therefore lower ambient levels of noise produced more outlier points.

Comparison Between Areas 1 and 2

Differences were observed between the two sample areas both in terms of noise distribution and overall levels of environmental noise. First, Adj L_{Aeq} values among area 1 sites presented greater overall variability than area 2 sites (Figure 2). This difference can be attributed to variations in traffic volume related to land use, background institutional noise, and pedestrian activity. The noisier sites in area 1 were located near major roads, while sites associated with less noise were located further from the same roads. Although area 2 evidenced higher overall levels of environmental noise, sample sites produced fairly consistent and stable noise recordings. The consistency in noise levels across sites in area 2 likely relates to land use and background noise. More specifically, area 2 produces greater levels of background noise throughout the day from vehicle traffic in the area, industrial sounds (e.g., ventilation fans), delivery trucks, and high pedestrian traffic. This is confirmed by the higher L_{A90} values (representing background noise) in area 2 in addition to higher Adj L_{Aeq} values as a result of land use.

Results indicate that area 1 is more influenced by the disturbance effect of noise events. For example, a moving vehicle may generate an increase in sound levels of 10.0–30.0 dB(A), which would certainly lead to residential disturbances in area 1, yet remain unnoticed in the higher background sound levels inherent to area 2. It should be mentioned that the composite full day rating (L_{Rden}) values for the two areas evidenced very little difference in daily sound exposure (area 1=63.8 dB(A); area 2=65.0 dB(A)).

Findings from the Kruskal–Wallis tests provide evidence of statistically different levels of environmental noise among sample sites in areas 1 and 2. Using the Mann–Whitney test, a significant difference in Adj L_{Aeq} values associated with area 1 (mdn=55.1) and area 2 (mdn=65.4) was obtained (U=102, p=0.0001, r=0.56), thus supporting the hypothesis that land use (e.g., built environments) affects levels of environmental noise.

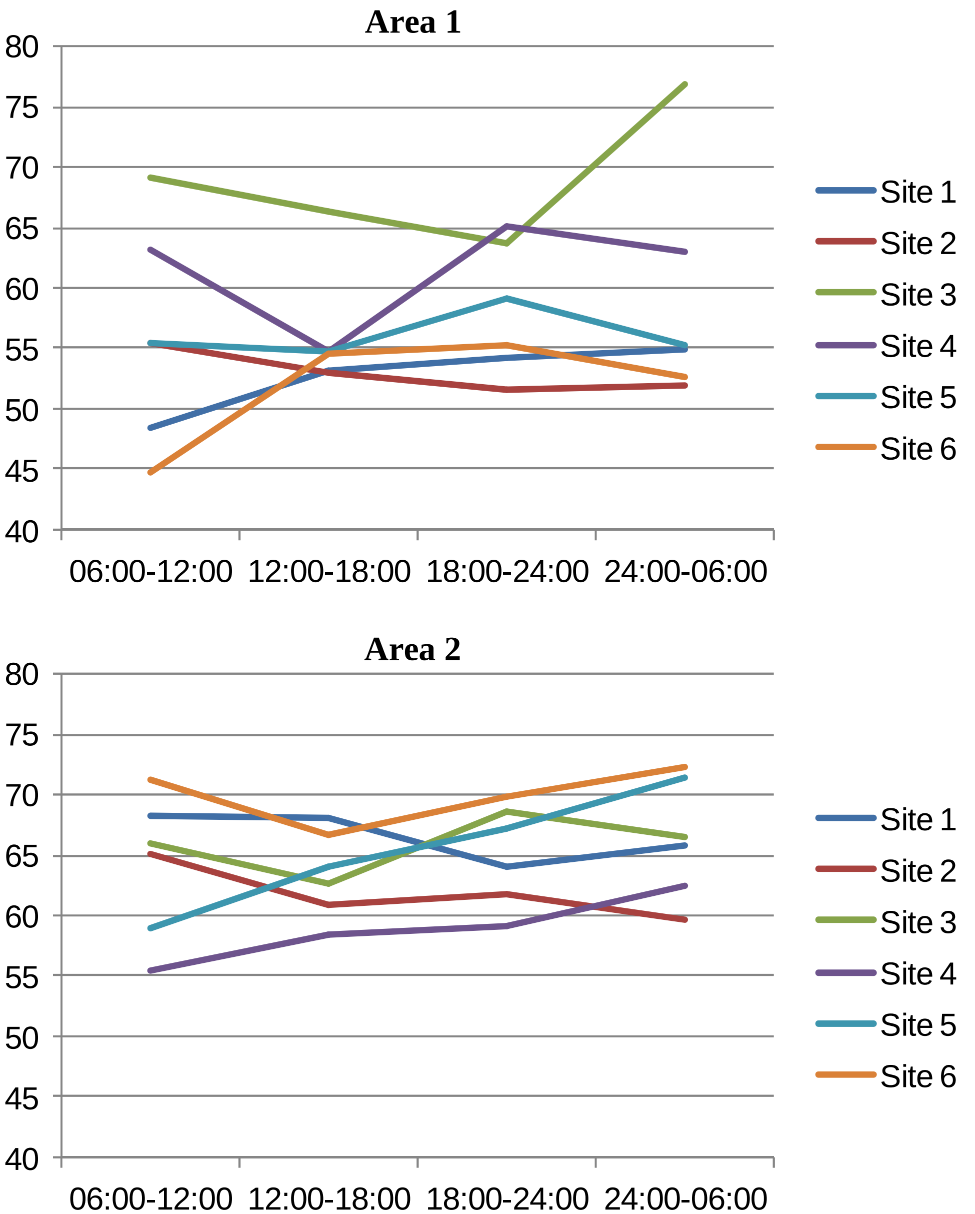

FIGURE 2. Adjusted L_{Aeq} values for areas 1 and 2.

DISCUSSION

The objective of the current research was to investigate and analyze spatial and temporal variations in environmental noise with respect to land use, specifically the built urban environment. In the analyses it was important to account for differences between neighborhood types in order to assess how increasing the frequency of mixed-used development land use would impact urban environmental noise levels. First, we found that noise levels varied significantly between residential and mixed-use neighborhoods. Noise levels in the mixed-use neighborhood were significantly greater than in the residential neighborhood. Second, noise values were analyzed to determine the spatial and temporal variability within and between sample sites. Greater variation in noise levels was found in the residential neighborhood. This reflected the co-location of the sound-level recording with major roads bounding the sample area, as well as specific traffic-related noise sources such as buses, trucks, and street cleaning equipment. Noise variation within the sample areas was much greater in the residential neighborhood.

Analyses revealed statistically significantly higher levels of environmental noise in the mixed-use neighborhood (area 2) compared to the predominantly residential neighborhood (area 1). Area 1 generated absolute environmental noise levels within the range of an office environment or normal conversation both of which are considered comfortable for human hearing. Area 2, on the other hand, produced higher absolute environmental noise levels considered, according to annoyance scales, intrusive and slightly annoying. Noise values were on average (L_{eq}) 8 db(A) greater during the day and 6 dB(A) greater during night-time hours in the mixed-use neighborhood. The higher overall levels of noise in area 2 likely reflect the continual presence of vehicular and pedestrian traffic in the area as well as background noise generated by institutional and industrial noise sources such as delivery trucks and ventilation systems. Evaluated against World Health Organization guidelines, both study areas yielded average noise events values in the moderate to serious annoyance range with the potential to obscure normal conversation and cause sleep disturbance.[14]

Our results also show significant variability in environmental noise *within* sample areas. With respect to area 1, environmental noise appeared to vary as a function of traffic patterns. For example, sites nearer to high traffic roads (e.g., heavy truck or bus traffic) presented higher levels of environmental noise. Because residential zones such as area 1 are associated with low(er) levels of background (i.e., continuous environmental noise) noise, traffic events can potentially contribute to high levels of disruption and disturbance. For example, people living close to site 3 in the residential area experienced on average a 10-dB(A) higher noise level during night-time hours compared to residents living elsewhere in the study area (Table 3). Site 3 is closest to two relatively major roads that are preferred routes for commuter, truck, and traffic from public transit (buses). In contrast, area 2 is associated with higher levels of background noise from steady traffic flow; consequently, results evidenced less intra-study area variability in noise despite the higher levels of noise associated with sites near high-traffic roads.

Our sampling approach also included measurement at random points within defined time periods to ensure sufficient noise measurements over a 24-h period. We did not find significant differences in average noise values across study sites within each sample area (Figure 2). Noise levels were somewhat higher during daytime hours, although the differences with evening and night-time measurements were minimized once values were adjusted. The consistency of noise values among day, evening, and night-time periods in urban environments has also been found in other studies.[20,25]

Although noise values in both study areas did not vary significantly over time, there was relatively good correspondence in the intensity of average adjusted values between areas for the time periods selected. For example, noise levels increased incrementally from the afternoon, through the evening, and peaked in the overnight hours for both study areas, even though there was an overall difference in absolute noise levels. In both areas, adjusted noise levels were greater in the overnight hours, particularly for the residential study area (area 1). Adjusted noise levels in the residential study area will be affected greatly by unusual noise sources, such as loud motorcycles, automobiles, or even bus traffic, since typical noise values are much lower throughout the day. Normally quiet neighborhoods in urban areas may thus be particularly prone to noise disturbances, especially during evening and night-time periods.

These findings support our initial hypothesis about the potential for variation in noise levels as a function of land use development in an urban environment. Urban planning initiatives developed to intensify urban development and promote mixed-use development may consider the potential for increased human exposure to noise and "design with noise in mind", especially as there is good evidence in support of an association between environmental noise and stress-related health effects.[7,9] When compared to guidelines designed to protect environmental quality and human health, adjusted noise levels in both areas exceed available recommended values for residential and mixed-use development and are indicative of relatively intensive land use development strategy (Table 5). Although Halifax is not a large city (population in 2006 of 372,675), noise levels in the mixed-use neighborhood are comparable to those measured in much larger urban centers such as Stockholm and Göteborg ($L_{Aeq,\ 24\mathrm{h}}$=62 dB),[26] San Fransisco (L_{dn}=65 dB),[12] and Vancouver ($L_{Aeq,\ 5\mathrm{min}}$=61.7 dB).[27]

From a public health perspective, noise levels measured in this study are of sufficient intensity to be injurious. For example, a 5-dB(A) increase in noise level between 45 and 65 dB(A) has been associated with a 38 % increased odds for hypertension even after control for several well-known risk factors.[28] The most deleterious health impacts arise from excessive noise exposures resulting in sleep disturbance. Sleep is a process of mental and physiological recovery essential to healthy functioning. It has been estimated that between 50 and 150 noise-induced awakenings per year may occur at outdoor noise levels equivalent to those measured in this study.[29] Subsequent impacts to health and well-being are numerous, including: impairment to cognitive performance, changes in hormone (epinephrine) levels, and changes in heart rate, sleep patterns, and mood. Ultimately, the constellation of noise-induced morbidities can lead to more severe health outcomes at noise levels not much greater than those measured in this study. Several studies have demonstrated an increased prevalence of cardiovascular diseases at noise levels as low as 70 dB(A).[9,30] Given the high prevalence of heart disease in Halifax, when compared to similar size cities in Canada, there is a clear rationale to investigate in more detail the level and distribution of noise for the rest of the city.

Certain study limitations may affect the generalizability of the results. First, noise levels were measured in two neighborhoods and within a limited time period. Increasing the number of study areas to include additional land-use types would provide a deeper understanding of the relationship between environmental noise, the built environment, and human health risks. Second, an extended sampling campaign could investigate the potential for seasonal variation on noise levels. For example, the source and character of environmental noise may change with weather and road conditions. Third, the collection of full 24-h samples would help to eliminate

TABLE 5 Study L_{Aeq} values[a] compared to noise exposure limits set by Italian legislation

	Area 1 (residential)		Area 2 (mixed use)	
	Noise exposure limits	L_{Aeq}	Noise exposure limits	L_{Aeq}
Day (06:00–22:00)	55.0	55.4	60.0	63.4
Night (22:00–06:00)	45.0	50.0	50.0	56.1

[a]Expressed in dB(A)

measurement error in the L_{Aeq} calculation. Future research should consider the variation of noise with land use in a similar fashion to air quality research to enable prediction of noise levels in locations without direct noise measurement. This approach could be complemented by interviews with neighborhood residents in order to investigate annoyance and the potential for noise-related human health risks.

Despite these limitations, this study provides important evidence concerning the relationship between land use and environmental noise. A planning strategy focused on mixed-use development may result in an increase in noise levels and human exposures to noise at levels with potential health implications. In a 2007 paper on urban growth and population health, the authors recommended the inclusion of urbanicity as a potential determinant of health.[31] Indeed, our findings suggest a sensitivity of residential areas to noise disruptions from such urban standards as traffic intensification. Municipal planning policies and initiatives should consider integrating traffic restrictions and controls in residential areas and school zones. At present there are no quantitative noise standards on which to compare measured noise levels or evaluate noise exceedances in Halifax, and all excess noise levels are controlled through a complaint driven process based on perceived noise levels. Municipal representatives should consider the institution of new environmental noise standards and policies in order to protect the health of residents and preserve urban environmental quality. Such policies could include improving the quality of mufflers on buses especially in light of findings that relate potentially harmful noise levels to mass transit systems.[32] Ideally, policy development and regulation should originate from sound planning and an inclusive multi-sectoral approach,[33] to protect and improve population health in increasingly urbanized living environments.

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REFERENCES

1. Northridge ME, Sclar ED, Biswas P. Sorting out the connections between the built environment and health: a conceptual framework for navigating pathways and planning healthy cities. *J Urban Health*. 2003; 80(4): 556.
2. Grimm NB, Faeth SH, Golubiewski NE, et al. Global change and the ecology of cities. *Science*. 2008; 319(5864): 756–760.
3. Galea S, Ahern J, Rudenstine S, Wallace Z, Vlahov D. Urban built environment and depression: a multilevel analysis. *J Epidemiol Commun H*. 2005; 59: 822–827.
4. Kaczynski A, Potwarka L, Saelens B. Association of park size, distance, and features with physical activity in neighborhood parks. *Am J Public Health*. 2008; 98: 1451–1456.
5. Dannenberg AL, Jackson JR, Frumkin H, et al. The impact of community design and land-use choices on public health. *Am J Public Health*. 2003; 93: 1500–1508.
6. Brown AL, Lam KC. Urban noise surveys. *Appl Acoust*. 1987; 20: 23–39.
7. Regecová V, Kellerová E. Effects of urban noise pollution on blood pressure and heart rate in preschool children. *J Hypertens*. 1995; 13: 405–412.
8. Stansfeld SA, Berglund B, Clark C, et al. Aircraft and road traffic and children's cognition and health: a cross-national study. *Lancet*. 2005; 365: 1942–1949.
9. Babisch W. Traffic noise and cardiovascular disease: epidemiological review and synthesis. *Noise Health*. 2000; 8: 9–32.

10. Dinno A, Powell C, King MM. A study of riders' noise exposure on a bay area rapid transit trains. *J Urban Health*. 2011; 88: 1–13.
11. de Coensel B, de Muer T, Yperman I, Botteldooren D. The influence of traffic flow dynamics on urban soundscapes. *Appl Acoust*. 2005; 66: 175–194.
12. Seto ETW, Holt A, Rivard T, Bhatia R. Spatial distribution of traffic induced noise exposures in a US city: an analytic tool for assessing the health impacts of urban planning decisions. *Int J Health Geogr*. 2007; 6: 24.
13. Michaud DS, Keith SE, McMurchy D. Annoyance and disturbance of daily activities from road traffic noise in Canada. *J Acoust Soc Am*. 2008; 123(2): 784–792.
14. World Health Organization (WHO) Guidelines for Community Noise. 1999. Available from: http://www.who.int/docstore/peh/noise/guidelines2.html
15. South Australia Office of Parliamentary Counsel. Environment Protection (Noise) Policy 2007. Available from: http://www.legislation.sa.gov.au/lz/c/pol/environment%20protection%20%28noise%29%20policy%202007/current/2007.-.un.pdf
16. U.S. Environmental Protection Agency. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. Washington, D.C: U.S. Environmental Protection Agency; 1974.
17. Frenkel A. The potential effect of national growth-management policy on urban sprawl and the depletion of open spaces and farmland. *Land Use Policy*. 2004; 21(4): 357–369.
18. Eid J, Overman HG, Puga D, Turner MA. Fat city: questioning the relationship between urban sprawl and obesity. *J Urban Econom*. 2008; 63(2): 385–404.
19. Stone J. Urban sprawl and air quality in large US cities. *J Environ Manage*. 2008; 86(4): 688–698.
20. Piccolo A, Plutino D, Cannistraro G. Evaluation and analysis of the environmental noise of Messina, Italy. *Appl Acoust*. 2005; 66: 447–465.
21. Gaja E, Gimenez A, Sancho S, Reig A. Sampling techniques for the estimation of the annual equivalent noise level under urban traffic conditions. *Appl Acoust*. 2003; 64: 43–53.
22. Miedema HME, Oudshoorn CGM. Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. *Environ Health Pers*. 2001; 109(4): 409–416.
23. Barrigon Morillas JM, Gomez Escobar V, Mendez Sierra JA, Vilchez GR, Trujillo CJ. An environmental noise study in the city of Caceres, Spain. *Appl Acoust*. 2002; 63: 1061–1070.
24. Ng CH, Tang SK. On monitoring community noise using arbitrarily chosen measurement periods. *Appl Acoust*. 2007; 69: 649–661.
25. Tsai K-T, Lin M-D, Chen Y-H. Noise mapping in urban environments. *Appl Acoust*. 2009; 70: 964–972.
26. Gildlöf-Gunnarsson A, Öhrström E. Noise and well-being in urban residential environments: the potential role of perceived availability to nearby green areas. *Land Urban Plan*. 2007; 83: 115–126.
27. Davies HW, Vlaanderen JJ, Henderson SB, Brauer M. Correlation between co-exposures to noise and air pollution from traffic sources. *Occup Environ Med*. 2009; 66: 347–350.
28. Bluhm GL, Berglind N, Nordling E, Rosenlund M. Road traffic noise and hypertension. *Occup Environ Med*. 2007; 64: 122–126.
29. Health Council of the Netherlands: Committee on an Uniform Noise Metric. Assessing Noise Exposure for Public Health Purposes [Omgevingslawaai besordelen]. nr 1997/23E. The Hague: Health Council of the Netherlands, 1997.
30. Babisch W, Beule B, Schust M, Kersten N, Ising H. Traffic noise and risk of myocardial infarction. *Epidemiol*. 2005; 16: 33–40.
31. Vlahov D, Freudenberg N, Proietti F, et al. Urban as a determinant of health. *J Urban Health*. 2007; 84(3): i16–i26.
32. Neitzel R, Gershon RR, Zeltser M, Canton A, Akram M. Noise levels associated with New York City's mass transit systems. *Am J Public Health*. 2009; 99: 1393–1399.
33. Northridge ME, Freeman L. Urban planning and health equity. *J Urban Health*. 2011; 88: 582–597.

EXHIBIT 5

ASHA
American
Speech-Language-Hearing
Association

Loud Noise Dangers

Loud noise can cause permanent hearing loss. There are ways to protect your hearing. Audiologists can help.

On this page:

About Noise-Induced Hearing Loss

Noise-Induced Hearing Loss, or NIHL, happens when you listen to loud sounds. These sounds can last a long time, like listening to a concert, or they can be short, like from gunfire. Three factors put you at risk for NIHL:

- How loud the noise is
- How close you are to the noise
- How long you hear the noise

Sound-level meters measure noise levels. We record noise levels in decibels, or dBA. The higher the noise level, the louder the noise. You can listen to sounds at 70 dBA or lower for as long as you want. Sounds at 85 dBA can lead to hearing loss if you listen to them for more than 8 hours at a time.

Sounds over 85 dBa can damage your hearing faster. The safe listening time is cut in half for every 3-dB rise in noise levels over 85 dBA. For example, you can listen to sounds at 85 dBA for up to 8 hours. If the sound goes up to 88 dBA, it is safe to listen to those same sounds for 4 hours. And if the sound goes up to 91 dBA, your safe listening time is down to 2 hours.

The World Health Organization and International Telecommunication Union 2019 document, WHO-ITU Global Standard on Safe Listening Devices and Systems [PDF], recommends that manufacturers equip devices like smartphones and personal audio players with information that explains safe listening (for adults, a total of 40 hours of weekly exposure to volume levels no higher than 80 dB is recommended; for children, the level is 75 dB); usage warnings and tracking information; cues for taking safe listening actions; options for limiting volume levels; and volume limiters expressly for parents to use. The recommendations would also have safe listening information appear on external product packaging and advertising, as well as on manufacturers' websites.

Citations

- World Health Organization, WHO-ITU global standard for safe listening devices and systems, 2019. Retrieved from https://www.who.int/deafness/make-listening-safe/standard-for-safe-listening/en/.
- U.S. Environmental Protection Agency, Office of Noise Abatement and Control. (1974, March). *Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety* Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi/2000L3LN.PDF?Dockey=2000L3LN.PDF [PDF].

Impulse Noise

A single loud blast or explosion that lasts for less than 1 second can cause permanent hearing loss right away. This noise, called impulse noise or impact noise, may come from gunfire or fireworks. We measure impulse noise in dB peak pressure, or dBP. Impulse noise greater than 140 dBP will hurt your hearing right away.

Dangerous and Safe Noise Levels

The noise chart below lists average decibel levels for everyday sounds around you.

Painful impulse noise—Not safe for any period of time

150 dBP = fireworks at 3 feet, firecracker, shotgun

140 dBP = firearms

Painful steady noise—Not safe for any period of time

130 dBA = jackhammer

120 dBA = jet plane takeoff, siren, pneumatic drill

Extremely loud—Dangerous to hearing; wear earplugs or earmuffs

112 dBA = maximum output of some MP3 players, rock concert, chainsaw

106 dBA = gas leaf blower, snow blower

100 dBA = tractor, listening with earphones

94 dBA = hair dryer, kitchen blender, food processor

Very loud—Dangerous to hearing; wear earplugs or earmuffs

91 dBA = subway, passing motorcycle, gas mower

Moderate—Safe listening for any time period

70 dBA = group conversation, vacuum cleaner, alarm clock

60 dBA = typical conversation, dishwasher, clothes dryer

50 dBA = moderate rainfall

40 dBA = quiet room

Faint—Safe listening for any time period

30 dBA = whisper, quiet library

The noise chart was developed using the following two websites:

- Noise Navigator
- Dangerous Decibels

Signs That Noise Is Too Loud

You probably don't always carry a sound level meter with you. So how can you know if noises are too loud? Here are some signs:

- You must raise your voice to be heard.
- You can't hear or understand someone 3 feet away from you.
- Speech around you sounds muffled or dull after you leave the noisy area.
- You have pain or ringing in your ears after you hear the noise, called tinnitus. It can last for a few minutes or a few days.

Noise and Hearing Loss

How do loud noises hurt your hearing? It may help to first understand how you hear:

- Sound goes into your ear as sound waves. The louder the sound, the bigger the sound wave.
- The outer ear, which is what you see on the side of your head, collects the sound wave. The sound wave travels down the ear canal toward your eardrum. This makes your eardrum vibrate.
- The sound vibration makes the three middle ear bones move. The movement makes the sound vibrations bigger.
- The last of the three middle ear bones moves the sound vibrations into the inner ear, or cochlea. The cochlea is filled with fluid and has tiny hair cells along the inside. The vibrations make the fluid in the inner ear move. The fluid makes the hair cells move, too. The hair cells change the vibrations into electrical signals that travel to your brain through your hearing nerve.
- Only healthy hair cells can send electrical signals to your brain. We recognize sounds in our brains and use that information to figure out how to respond.

You may lose some of your hearing if the hair cells get damaged. How does this happen?

- Hair cells are sensitive to big movements. If sounds are loud, they move the fluid in the inner ear more, and that can damage the hair cells.
- Hair cells that are damaged by loud sounds do not send signals to the brain as well as they should. The first hair cells that are hurt are those that send high-pitched sounds to the brain. This can make sounds like /t/ in "tin", /f/ in "sin", or /k/ in "kin" harder to hear.
- Short, loud noises—like a firecracker or an explosion—can damage hair cells. Listening to loud sounds for a long time, like when you are at a rock concert, also damages hair cells.

Ringing in your ears, or tinnitus, is an early sign of noise-induced hearing loss. There is no way to fix damaged hair cells. Hearing aids or other devices can help you hear better, but your hearing will not come back on its own.

Noise and Your Health

Loud noise does not just hurt your hearing. It can cause other problems that you may not think of as being noise related.

Noise can make you more tired and cranky. Loud noise can cause other health problems, like:

- high blood pressure
- faster heart rate
- upset stomach
- problems sleeping, even after the noise stops
- problems with how babies develop before birth

Noise can make it harder to pay attention. You may be less safe at work because you may not hear warning signals or equipment problems. Noise can also cause you to get less work done.

Noisy classrooms can make it harder for children to learn. To learn more about noise in schools, read the Classroom Acoustics page.

It is harder to understand what others say when it is noisy. You may need to concentrate more and use more energy to hear. And the person speaking needs to talk louder or yell. This can make conversations hard. You may give up trying to talk or listen.

So, you can see that noise does more than cause hearing loss. It can impact your health, work, learning, and social life. It is important to cut down on the noise in your life for all of these reasons.

Protecting Your Hearing

Knowing how noise impacts you is the key to protecting your hearing. You've taken that first step by reading this information.

The next step is to avoid loud noise whenever possible. Remember, if you have to shout to be heard, it is too loud. You should get away from the noise or find a way to protect your ears.

Here are some things you can do:

1. **Wear hearing protection.** Cotton in the ears will not work. You can buy things that protect your hearing, like earplugs or earmuffs, at the store or online.
    - **Earplugs** go **into** your ear so that they totally block the canal. They come in different shapes and sizes. An audiologist can make some just for your ears. Earplugs can cut noise down by 15 to 30 decibels.
    - **Earmuffs** fit completely **over** both ears. They must fit tightly to block sound from going into your ears. Like earplugs, earmuffs can reduce noise by 15 to 30 dB, depending on how they are made and how they fit.
    - **Earplugs and earmuffs** can be used together to cut noise down even more. You should use both when noise levels are above 105 dB for 8 hours or more. You should also use both if you might hear impulse sounds that are more than 140 dBP.

2. **Do not listen to loud sounds for too long.** Move away from the loud sound if you don't have hearing protection. Give your ears a break. Plug your ears with your fingers as emergency vehicles pass on the road.

3. **Lower the volume.** Keep personal listening devices set to no more than half volume. The World Health Organization recommends a total of 40 hours of weekly exposure to volume levels no higher than 80 dB for adults and 75 dB for children on personal listening devices. Don't be afraid to ask others to turn down the volume of their devices if you can hear them. Ask the movie theater manager to turn down the sound if the movie is too loud.

4. **Be a good consumer.** Look for noise ratings on appliances, sporting equipment, power tools, and hair dryers. Buy quieter products. This is especially important when buying toys for children.

5. **Be a local advocate.** Some movie theaters, health clubs, dance clubs, bars, and amusement centers are very noisy. Speak to managers about the loud noise and how it may hurt hearing. Ask that they turn the volume down.

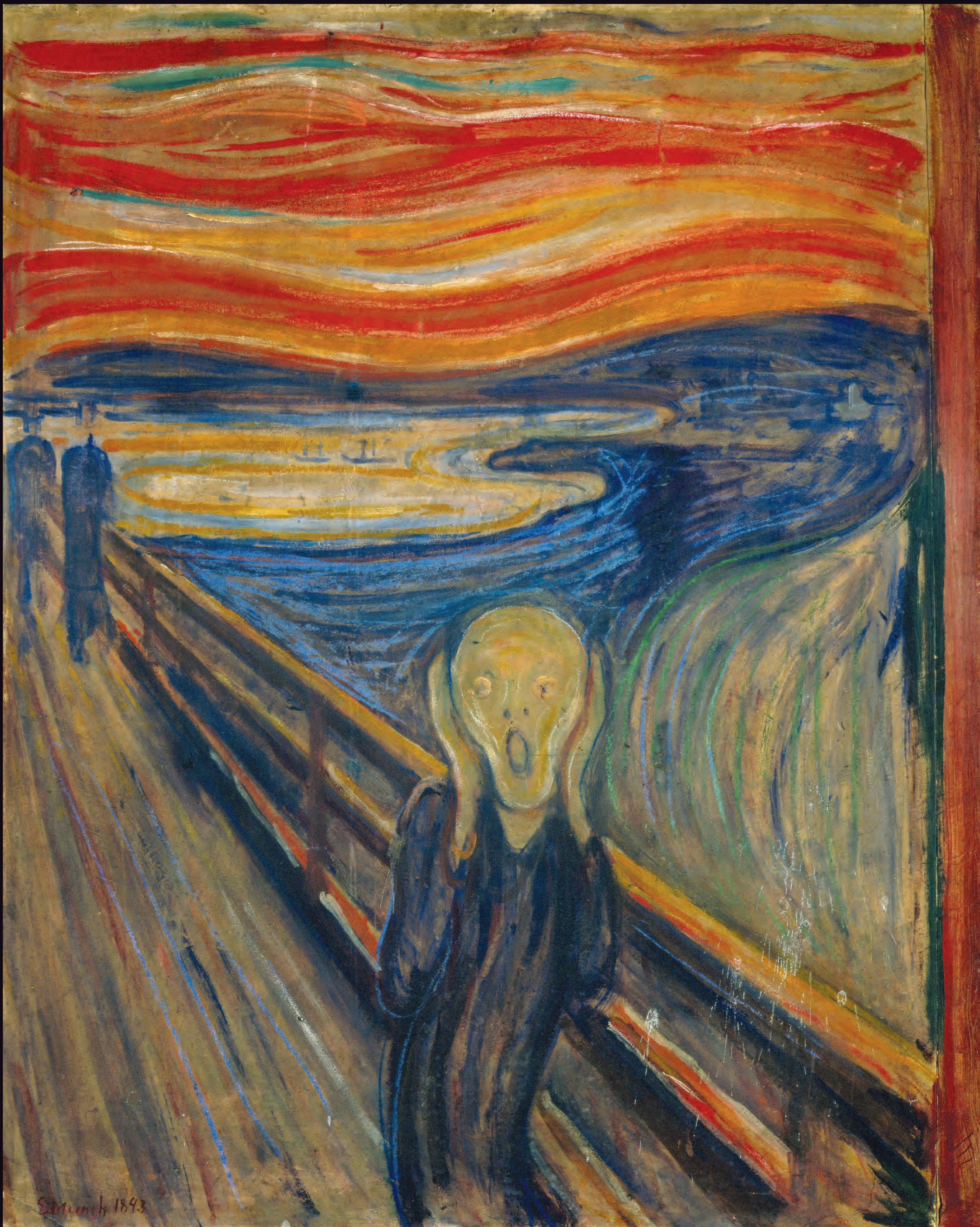
Don't be fooled by thinking your ears are "tough" or that you can "tune it out"! Noise-induced hearing loss is usually slow and painless. But, it is permanent. The hair cells and hearing nerve cannot be fixed. If loud sounds don't bother you, you may already have some hearing damage.

You can avoid noise-induced hearing. Protect your hearing for life.

More information on this topic can be found in our Audiology Information Series [PDF].

To find an audiologist near you, visit ProFind.

EXHIBIT 6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Decibel Hell

The Effects of Living in a Noisy World

It's not difficult for a person to encounter sound at levels that can cause adverse health effects. During a single day, people living in a typical urban environment can experience a wide range of sounds in many locations, including shopping malls, schools, the workplace, recreational centers, and the home. Even once-quiet locales have become polluted with noise. In fact, it's difficult today to escape sound completely. In its 1999 *Guidelines for Community Noise*, the World Health Organization (WHO) declared, "Worldwide, noise-induced hearing impairment is the most prevalent irreversible occupational hazard, and it is estimated that 120 million people worldwide have disabling hearing difficulties." Growing evidence also points to many other health effects of too much volume.

The growing noise pollution problem has many different causes. Booming population growth and the loss of rural land to urban sprawl both play a role. Other causes include the lack of adequate anti-noise regulations in many parts of the world; the electronic nature of our age, which encourages many noisy gadgets; the rising number of vehicles on the roads; and busier airports. The U.S. Environmental Protection Agency (EPA) has long identified transportation—passenger vehicles, trains, buses, motorcycles, medium and heavy trucks, and aircraft—as one of the most pervasive outdoor noise sources, estimating in its 1981 *Noise Effects Handbook* that more than 100 million people in the United States are exposed to noise sources from traffic near their homes.

Some experts define noise simply as "unwanted sound," but what can be unwanted for one person can be pleasant or even essential sound to to another—consider boom boxes, car stereos, drag races, and lawn mowers in this context. Sound intensity is measured in decibels (dB); the unit A-weighted dB (dBA) is used to indicate how humans hear a given sound. Zero dBA is considered the point at which a person begins to hear sound. A soft whisper at 3 feet equals 30 dBA, a busy freeway at 50 feet is around 80 dBA, and a chain saw can reach 110 dBA or more at operating distance. Brief exposure to sound levels exceeding 120 dBA without hearing protection may even cause physical pain.

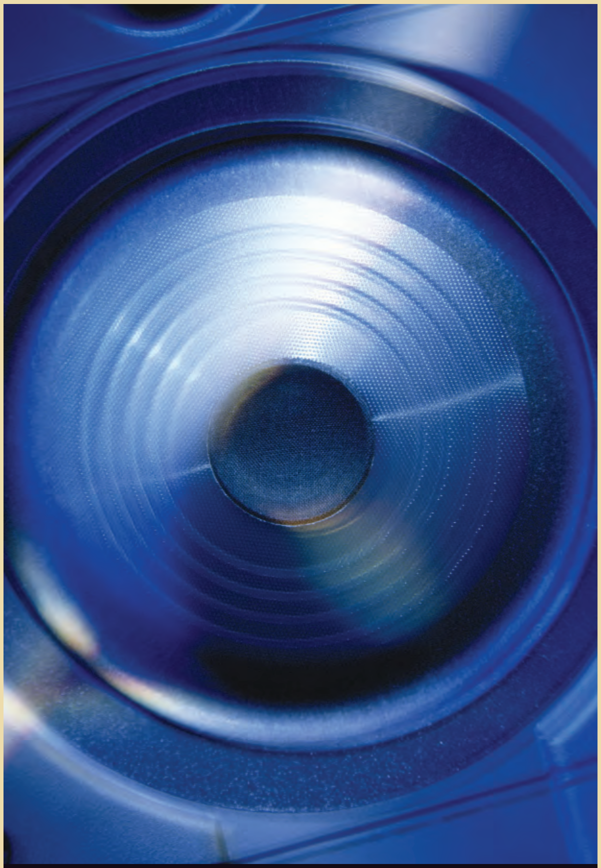
Mark Stephenson, a Cincinnati, Ohio–based senior research audiologist at the National Institute for Occupational Safety and Health (NIOSH), says his agency's definition of hazardous noise is sound that exceeds the time-weighted average of 85 dBA, meaning the average noise exposure measured over a typical eight-hour work day. Other measures and definitions are used for other purposes. For example, "sound exposure level" accounts for variations in sound from moment to moment, while "equivalent sound level" determines the value of a steady sound with the same dBA sound energy as that contained in a time-varying sound.

Growing Volume

In the United States, about 30 million workers are exposed to hazardous sound levels on the job, according to NIOSH. Industries having a high number of workers exposed to loud sounds include construction, agriculture, mining, manufacturing, utilities, transportation, and the military.

Noise in U.S. industry is an extremely difficult problem to monitor, acknowledges Craig Moulton, a senior industrial hygienist for the Occupational Safety and Health Administration (OSHA). "Still," he says, "OSHA does require that any employer with workers overexposed to noise provide protection for those employees against the harmful effects of noise. Additionally, employers must implement a continuing, effective hearing conservation program as outlined in OSHA's Noise Standard."

Meanwhile, there is no evidence to suggest things have gotten any quieter for residents since the EPA published its 1981 handbook. "For many people in the United States, noise has drastically affected the quality of their lives," says Arline L. Bronzaft, chair of the Noise Committee of the New York City Council of the Environment and a psychologist who has done pioneering research on the effects of noise on children's reading ability. "My daughter lives near La Guardia airport in New York City, and she can't open a window or enjoy her backyard in the summer because of the airplane noise."



On the street. Booming bass is quickly becoming the soundtrack of urban life.

On the increase. Our technological society encourages the propagation of noisy devices, and children are being exposed earlier than ever to an abundance of electronic noise.

Indeed, the term *secondhand noise* is increasingly used to describe noise that is experienced by people who did not produce it. Anti-noise activists say its effect on people is similar to that of secondhand smoke. "Secondhand noise is really a civil rights issue," says Les Blomberg, executive director of the Noise Pollution Clearinghouse, an anti-noise advocacy group based in Montpelier, Vermont. "Like secondhand smoke, it's put into the environment without people's consent and then has effects on them that they don't have any control over."

Secondhand noise can also have a negative effect in the workplace. "Workers in the construction trades get exposure to noise not just from what they are doing but also from what is going on around them," says Rick Neitzel, director of communications for the National Hearing Conservation Association. "Electricians, for example, have a reputation as being a member of a quiet trade, but if they work all day next to a laborer who is using a jackhammer, it's going to have a harmful effect."

Even disregarding other people's noise, there are any number of household tools

Top to bottom: Photodisc; Photodisc

and appliances that can produce harmful sound levels in the comfort of one's own home. According to the fact sheet "Noise in the Home" produced by the League for the Hard of Hearing, dishwashers, vacuum cleaners, and hair dryers can all reach or exceed 90 dBA.

Our modern industrialized society has spawned ubiquitous entertainment and sports industries with their boom boxes, "personal stereos" (Gap Kids now even offers a jacket with a built-in radio and speakers conveniently attached right in the hood), surround-sound movie theaters, loud TV commercials, and even louder commercials at sports stadiums crammed full of thousands of noisy fans. In drag racing, a growing international sport, a German team of audio engineers set an ear-splitting record of 177 dB–sound pressure level in 2002. Popular "boom cars" equipped with powerful stereo systems that are usually played with the volume and bass turned up abnormally high and the car windows rolled down can hit 140–150 dBA. Listening to music at a level of 150 dBA would be like standing next to a Boeing 747 airplane with its engines at full throttle, according to statistics provided by Noise Free America, an anti-noise advocacy group.

Even the countryside is not immune to the impact of noise pollution. According to the New York Center for Agricultural Medicine and Health in Cooperstown, a staggering 75% of farmworkers have some kind of hearing problem, largely the result of long-term exposure to loud equipment.

The United States is not the only country where noise pollution is affecting the quality of life. In Japan, for instance, noise pollution caused by public loudspeaker messages and other forms of city noise have forced many Tokyo citizens to wear earplugs as they go about their daily lives. In Europe, about 65% of the population is exposed to ambient sound at levels above 55 dBA, while about 17% is exposed to levels above 65 dBA, according to the European Environment Agency.

"The noisy problems associated with air travel are concentrated in communities around airports, whereas motorways or high-speed trains—traveling, for instance, from north to south Europe—have the potential to disturb thousands of people living along the route day after day," says Ken Hume, a principal lecturer in human physiology at the Manchester Metropolitan University in England.

Noise is indeed everywhere, and experts expect no decrease in noise levels, given the powerful impact of technology on modern life. "In the past three decades, we have built noisier and noisier devices that are not subject to any regulations," Blomberg says. "Think about it. The car alarm is a seventies invention, as is the leaf blower. The stereo sound systems we have in our cars are much louder than the sound system the Beatles used for their concerts in the sixties. All they had back then were three-hundred-amp speakers."

Counting Decibels

Device/Situation	dBA*
Grand Canyon at night, no birds, no wind	10
Quiet room	28–33
Computer	37–45
Floor fan	38–70
Refrigerator	40–43
Normal conversation	40
Forced-air heating system	42–52
Radio playing in background	45–50
Clothes washer	47–78
Dishwasher	54–85
Bathroom exhaust fan	54–55
Microwave oven	55–59
Normal conversation	55–65
Laser printer	58–65
Hair dryer	59–90
Window fan on "high" setting	60–66
Alarm clock	60–80
Vacuum cleaner	62–85
Push reel mower	63–72
Sewing machine	64–74
Telephone	66–75
Food disposal	67–93
Inside car with windows closed, traveling at 30 miles per hour	68–73
Handheld electronic game	68–76
Inside car with windows open, traveling at 30 miles per hour	72–76
Electric shaver	75
Air popcorn popper	78–85
Electric lawn edger	81
Electric can opener	81–83
Gasoline-powered push lawn mower	87–92
Average motorcycle	90
Air compressor	90–93
Weed trimmer	94–96
Leaf blower	95–105
Circular saw	100–104
Maximum output of stereo	100–120
Chain saw	110
Average snowmobile	120
Average fire crackers	140
Average rock concert	140

* Measurements are approximate and may vary by source.

Sources: National Institute on Deafness and Other Communication Disorders, Environmental Protection Agency, Noise Pollution Clearinghouse.

On the job. Occupational noise is pervasive throughout many industries and may cause serious damage despite regulations to protect workers' hearing.

Digital Vision

Scary Sound Effects

Numerous scientific studies over the years have confirmed that exposure to certain levels of sound can damage hearing. Prolonged exposure can actually change the structure of the hair cells in the inner ear, resulting in hearing loss. It can also cause tinnitus, a ringing, roaring, buzzing, or clicking in the ears. The American Tinnitus Association estimates that 12 million Americans suffer from this condition, with at least 1 million experiencing it to the extent that it interferes with their daily activities.

NIOSH studies from the mid to late 1990s show that 90% of coal miners have hearing impairment by age 52—compared to 9% of the general population—and 70% of male metal/nonmetal miners will experience hearing impairment by age 60 (Stephenson notes that from adolescence onward, females tend to have better hearing than males). Neitzel says nearly half of all construction workers have some degree of hearing loss. "NIOSH research also reveals that by age twenty-five, the average carpenter's hearing is equivalent to an otherwise healthy fifty-year-old male who hasn't been exposed to noise," he says.

"Noise has an insidious effect in that the more exposure a person has to noise, the more the hearing loss will continue to grow," says Josara Wallber, disabilities services liaison for the National Technical Institute for the Deaf in Rochester, New York. "Hearing loss is irreversible. Once hearing is lost, it's lost forever."

William Luxford, medical director of the House Ear Clinic of St. Vincent Medical Center in Los Angeles, points out one piece of good news: "It's true that continuous noise exposure will lead to the continuation of hearing loss, but as soon as the exposure is stopped, the hearing loss stops. So a change in environment can improve a person's hearing health."

For many young people, changing their environment and their behavior would be a wise and healthy move. That's because audiologists are fitting more and more of them with hearing aids, says Rachel Cruz, a research associate at the House Ear Clinic. She says audiologists are blaming this disturbing development on youth's penchant for listening to loud music, especially with the use of headphones.

Research is catching up with this anecdotal evidence. In the July 2001 issue of *Pediatrics*, researchers from the Centers for Disease Control and Prevention reported that, based on audiometric testing of 5,249 children as part of the Third National Health and Nutrition Examination Survey, an estimated 12.5% of American children have noise-induced hearing threshold shifts—or dulled hearing—in one or both ears. Most children with noise-induced hearing threshold shifts have only limited hearing damage, but continued exposure to excessive noise can lead to difficulties with high-frequency sound discrimination. The report listed stereos, music concerts, toys (such as toy telephones and certain rattles), lawn mowers, and fireworks as producing potentially harmful sounds.

For the baby boom generation, on the other hand, a change of environment may be too late. "Many baby boomers began losing their hearing when the amplification of popular music came into vogue in the nineteen sixties," says Cruz. "We are starting to see that a lot of musicians and audio engineers who have been involved with popular music for a long time are having hearing problems." Cruz is gathering data for a research study to examine how these professionals' occupational sound exposures affect their hearing over a span of years.

Beyond the Ears

The effects of sound don't stop with the ears. Nonauditory effects of noise exposure are those effects that don't cause hearing loss but still can be measured, such as elevated blood pressure, loss of sleep, increased heart rate, cardiovascular constriction, labored breathing, and changes in brain chemistry. According to the WHO *Guidelines for Community Noise*, "these health effects, in turn, can lead to social handicap, reduced productivity, decreased performance in learning, absenteeism in the workplace and school, increased drug use, and accidents."

The nonauditory effects of noise were noted as early as 1930 in a study published by E.L. Smith and D.L. Laird in volume 2 of the *Journal of the Acoustical Society of America*. The results showed that exposure to noise caused stomach contractions in healthy human beings. Reports on noise's nonauditory effects published since that pioneering study have been both contradictory and controversial in some areas.

Data pertaining to whether noise can increase the risk of damage to the fetus is a case in point. A study published by L.D. Edmonds, P.M. Layde, and J.D. Erickson in the July–August 1979 issue of the *Archives of Environmental Health* found no significant data suggesting an effect of noise on fetal development in pregnant women who lived near airports. But in the October 1997 issue of *Pediatrics*, the Committee on Environmental Health of the American Academy of Pediatrics published a policy statement based on a review of research on the potential health effects of noise on the fetus and the newborn. The committee concluded that excessive noise exposure *in utero* may result in high-frequency hearing loss in newborns and further that excessive sound levels in neonatal intensive care units may disrupt the natural growth and development of premature infants. It recommended that noise-induced health effects on fetuses and newborns are clinical and public health concerns that merit further study.

Studies have revealed that as children grow they are exposed to sounds that can threaten their health and cause learning problems. For instance, in the September 1997 issue of *Environment and Behavior*, Cornell University environmental psychologists Gary Evans and Lorraine Maxwell reported that the constant roar of jet aircraft could cause higher blood pressure, boosted stress levels, and other effects with potential life-long ramifications among children living in areas under the flight paths of airport.

Other human and animal studies also have linked noise exposure to chronic changes in blood pressure and heart rate. For example, in the July–August 2002 issue of the *Archives of Environmental Health,* a team of government and university researchers concluded that exposure to sound "acts as a stressor—activating physiological mechanisms that over time can produce adverse health effects. Although all the effects and mechanisms are not elucidated, noise may elevate systolic blood pressure, diastolic blood pressure, and heart rate, thus producing both acute and chronic health effects."

Noise has also been shown to affect learning ability. In 1975 Bronzaft collaborated on a study of children in a school near an elevated train track that showed how exposure to noise can affect children's reading ability. Half of the students in the study were in classrooms facing the train track and the other half were in classrooms in the school's quieter back section. The findings, published in the December 1975 issue of *Environment and Behavior*, were that students on the quieter side performed better on reading tests, and by sixth grade they were a full grade point ahead of the students in the noisier classrooms.

Bronzaft and the school principal persuaded the school board to have acoustical tile installed in the classrooms adjacent to the tracks. The Transit Authority also treated the tracks near the school to make them less noisy. A follow-up study published in the September 1981 issue of the *Journal of Environmental Psychology* found that children's reading scores improved after these interventions were put in place. "After we did the study, more than twenty-five other studies were done examining the effect of noise on children's learning ability," Bronzaft says. "They have all found the same thing to be true: noise can affect children's learning."

The EPA reported in the *Noise Effects Handbook* that surveys taken in communities significantly affected by noise indicated that interruption of sleep was the underlying cause of many people's complaints. Research has shown that unwanted sound is most annoying at the times when people expect to rest or sleep, that it can interrupt or delay sleep, and that it can have subtle effects on sleep, such as causing shifts from deeper to lighter sleep stages. "The research is pretty solid that noise can prevent people from getting a good night's sleep," Hume says. "I believe that sleep deprivation can have negative health effects when it becomes a chronic problem."

Fighting for Quiet

Worldwide, airports have become a flash point for community frustration over noise pollution. In September 2002, officials at the Frankfurt am Main Airport in Germany received 56,330 noise-related complaints, a 30% increase over the same month in 2001. The same year, residents living near a rural airport outside London, England, were

On the go. Transportation sound is perhaps the largest contributor to urban noise pollution.

Top to bottom: Digital Vision; Digital Vision

On the way up. Problems from airplane and airport noise are increasing as more and more flights take off over residential areas.

submitting 100 petitions daily, objecting to proposals for three new runways at the site.

In March 2003, representatives from eight neighborhoods in Portland, Oregon, showed up for a city council hearing convened to discuss dozens of expansion projects for Portland International Airport. The airport was already a busy one: in 2002 it handled 12.2 million passengers and about 29,000 containers of air cargo. "The impacts are tremendous on the neighborhoods under the flight paths," testified one neighborhood representative, Jean Ridings. "People move in and move [right back] out. It's becoming a disaster." In response, the airport has initiated a multiyear, multimillion-dollar effort to study the sound impact of the airport, which locals hope will lead to a plan to reduce airport noise.

Noise Free America is seeking to file a class-action lawsuit against the makers of boom car equipment. Ted Rueter, Noise Free America's director and an assistant professor of political science at DePauw University in Greencastle, Indiana, says one group member has written a legal brief on the topic and has approached several public-interest law firms seeking representation, with no takers so far. Rueter says Noise Free America will continue to pursue the suit.

A lot of money is being made from disturbing the peace, charges Mark Huber, communications director for Noise Free America. "By using paid lobbyists in Washington, D.C., and in state legislatures, the automobile and entertainment industries are quietly removing obstacles protecting the public against noise," Huber says. "Try to get a noise control law passed through a state legislature and see what happens. We tried to get a boom car law enacted in the Virginia General Legislature, but right here in Richmond there are at least fifty car clubs, all of which are politically active. So our legislation disappeared."

Stephen McDonald, vice president of government affairs for the Washington, D.C.–based Specialty Equipment Market Association (SEMA), denies that any powerful lobby exists and is working against the best interests of society. SEMA represents manufacturers, distributors, retailers, and installers of specialty automotive equipment, including boom car equipment. "Our prime focus is representing the interests of businesses that sell exhaust systems," McDonald says. "But that doesn't mean we want the products to increase noise to a level where it becomes objectionable. We do need to strike a balance, though, between what is acceptable for a neighborhood and what's fair to people who want to customize their cars."

Anti-noise activists say that Europe and several countries in Asia are more advanced than the United States in terms of combating noise. "Population pressure has prompted Europe to move more quickly on the noise issue than the United States has," Hume says. In the European Union, countries with cities of at least 250,000 people are creating noise maps of those cities to help leaders determine noise pollution policies. Paris has already prepared its first noise maps. The map data, which must be finished by 2007, will be fed into computer models that will help test the sound impact of street designs or new buildings before construction begins.

In the United States, the Noise Control Act of 1972 empowered the EPA to determine noise limits to protect the public health and welfare, and to establish a noise control office. Congress did establish the Office of Noise Abatement and Control (ONAC), as well as federal standards for business, industries, and communities, and it did begin researching the effects of sound exposures. In 1982, however, the Reagan administration defunded the office. "We are no longer doing research on noise," says Kenneth Feith, an EPA senior scientist and policy advisor. "We just don't have the money or staff to do it."

Activists believe that closing the ONAC has had a tremendous negative effect at the state and local level. "The U.S. has long since given up its lead in regulating noise, and because of that there has been no consistency in implementing local noise regulations," Huber says. The Noise Control Act, though still on the books, is essentially toothless.

In the mid-1990s, people in the borough of Queens, New York, who lived under the flight paths of La Guardia Airport, took their concerns about noise to Representative Nina Lowey (D–NY). "I could see that noise is a serious public health issue, and so I decided to do something about it," Lowey says. In 1997 the congresswoman introduced legislation that's become known as the Quiet Communities Act (HR 536), which provided for the refunding of the ONAC and for $21 million to be spent annually on noise reduction. Among other measures, the money would be used to carry out a national noise assessment program to

Digital Vision

identify trends in noise exposure and response, develop and disseminate information and public education materials on the health effects of noise, and establish regional technical assistance centers, which would use the resources of universities and private organizations to assist state and local noise control programs.

"More and more communities are being affected by airports, trains, and railways," Lowey says. "We need a national office to coordinate policy. That's common sense to me. The federal government has to play a larger role on the noise issue. Otherwise, we will continue to lag behind other parts of the world in combating noise." While Lowey remains optimistic that the legislation will eventually pass, other sources doubt that it will happen, noting that the proposed legislation has been introduced and rejected several times.

Activists in other countries say they too want the United States to play a more leading role on the noise issue. "Re-establishing the ONAC would be a huge move in the right direction," says Hans Schmid, the Vancouver, Canada–based president of the Right to Quiet Society. "That will show that the United States is serious about the noise issue. If the United States leads, other countries, especially Canada, will follow."

But as in other areas of environmental health, merely having a more powerful government agency in place that can set more regulations is not the ultimate answer, according to other experts. Regulations provide an important foundation, Stephenson says, but better education of workers, consumers, businesses, and citizens is critical. "We've found that in some factories as many as one-third of the workers who have significant hearing loss don't wear hearing protectors, even though the factory has a comprehensive hearing conservation program in place," he says.

On the mend? Hospitals can be some of the noisiest public locations, but some health care facilities are actively fighting noise in the interest of better patient care.

Photodisc

Bronzaft stresses that governments worldwide need to increase funding for noise research and do a better job coordinating their noise pollution efforts so they can establish health and environmental policies based on solid scientific research. "Governments have a responsibility to protect their citizens by curbing noise pollution," she says.

Feith agrees. "The EPA had a successful educational program in the nineteen seventies in which we went to schools and educated students about noise," he says. "When students took the message home, they helped increase the sensitivity to the noise issue. We need more programs like that to educate the public about noise."

In the meantime, some facilities are doing what they can to help themselves to a quieter environment. Although peace and quiet are essential prerequisites for a healing environment, a Mayo Clinic study published in the February 2004 issue of the *American Journal of Nursing* showed that peak noise levels during the clinic's morning shift change rivaled the excruciating sound of a jackhammer. The study further showed that a few simple changes—for example, holding staff reports at shift change in an enclosed room (rather than at the nurses' station) and replacing roll-type paper towel dispensers with quieter models—reduced peak noise levels at shift change by 80%.

Similarly, the din of overhead pagers, which can reach 80 dBA, inspired the developers of the Woodwinds Health Campus in Woodbury, Minnesota, to build the facility with a staff location sensor and badge system, among other sound-friendly features. Staff can be located in just about any area of the Woodwinds campus without being paged. "We have developed an innovative approach to reducing noise in our hospital while fostering a healing environment," says Cindy Bultena, executive lead of healing and clinical coordination for Woodwinds. "Our change sounds simple enough, but it's a very radical one for hospitals."

By delivering their patients and staff from decibel hell, facilities like Woodwinds and the Mayo Clinic have scored one small victory in the ongoing battle against noise pollution. Their initiative, moreover, shows that given the pervasiveness and harmful effects of noise, governments, communities, and organizations worldwide will need to be creative and aggressive in addressing what will certainly continue to be one of the 21st century's most important environmental health issues.

Ron Chepesiuk

EXHIBIT 7

TRAINING FOR HEALTH CARE PROVIDERS

[Date …Place …Event…Sponsor…Organizer]

CHILDREN AND NOISE

Children's Health and the Environment

WHO Training Package for the Health Sector

World Health Organization

www.who.int/ceh

1

<<NOTE TO USER: Please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation in the space indicated.>>

This presentation on Children and Noise is part of a comprehensive set of training materials for health care providers on children, the environment and health.

<<NOTE TO USER: This is a large set of slides from which the presenter should select the most relevant ones to use in a specific presentation. These slides cover many facets of the problem. Present only those slides that apply most directly to the local situation in the region. It is also very useful if you present regional/local examples of noise prevention programs, if available, and choose local relevant pictures.>>

CONTENTS

LEARNING OBJECTIVES

To **understand**, **recognize** and **know**

1. Definition and characteristics of sound and noise
2. Sources and settings of noise exposure
3. Adverse effects of noise exposure
   - On physical health
   - On psychological health
   - On cognition
4. **Weight of the evidence of the harm to children**
   - **Special vulnerability of children**
   - **Various noise exposure scenarios in settings where children develop**
5. Interventions and preventive strategies

These are the learning objectives for this module. After the presentation, the audience should understand, recognize and know

<<READ SLIDE>>

CONTENTS

Children and noise

DEFINITION: SOUND AND NOISE

Sound is characterized by:

- ❖ Vibration
  - Frequency (**Hz**)
  - Intensity (Pa or **dB**)
    - Decibel scale logarithmic
    - Begins at threshold of hearing
- ❖ Periodicity
- ❖ Duration

NASA

"Noise is an unwanted or objectionable sound"

5

What is sound? Sound is a mechanic vibration propagated by elastic media (as air and water) which alters the pressure displacing the particles, and can be recognized by a person or an instrument.

Vibration and noise can never be separated but vibration can exist without audible noise.

Sound is characterized by its intrinsic characteristics:

•**Vibration:** Sound is a mechanic vibration, expressed as a combination of pressure (Pascals, Pa) and frequency (Hertz, Hz)

•**Frequency** or pitch is the number of cycles per second (Hertz, Hz or kilo Hertz, KHz).

•**Intensity** or loudness is the "level of sonorous pressure" and is measured in Pascals (Pa) or decibels (dB). The audible spectrum of the human ear is between 0.00002 Pa (corresponds to 0 dB) and 20 Pa (corresponds to 120 dB). The intensity of human speech is approximately 50 dB. Decibels are used for convenience to express sound on a compressed, logarithmic scale in the human audible spectrum.

•**Periodicity:** describes the pattern of repetition of a sound within a period of time: short sounds that are repeated.

•**Duration**: is the acoustic sense developed by the continuity of a sound in a period of time, for example music, voice or machinery.

What is noise? Noise is an unwanted or objectionable sound. Generally, the acoustic signals that produce a pleasant sense (music, bells) are recognized as "sound" and the unpleasant sounds as "noise" (for example: produced by a machine or airplane). It can be a pollutant and environmental stressor, and the meaning of sound is important in determining reaction of different individuals to the same sound. One person's music is another's noise.

The human ear is an instrument that detects vibration within a set range of frequencies. Air, liquid or solid propagates vibration; without them, sound does not exist. Sound does not exist in the vacuum. The higher the level of pressure of the sonorous wave, the shorter the period of time needed to be perceived by the ear.

Why are not all vibrations audible?

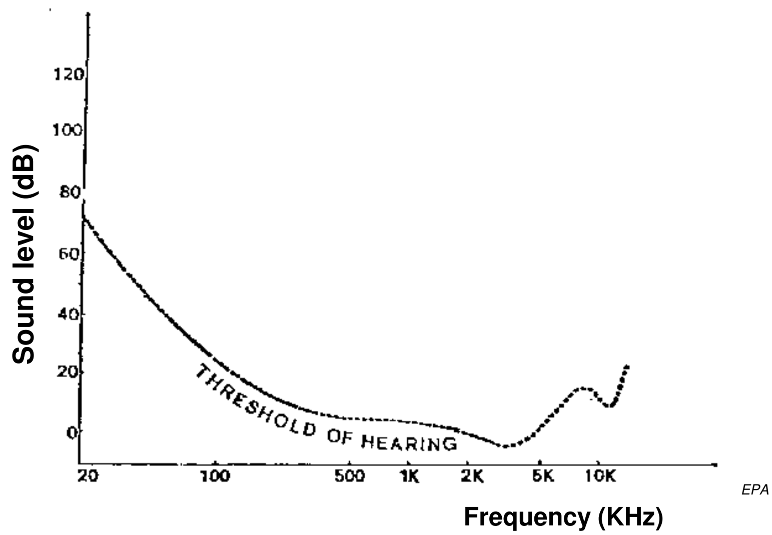
The ear is a frequency analyzer. The eardrum separates tone and conduction in two different ways: by the nervous system and by the bones. The nervous system connects the cochlea to the temporal region of both hemispheres of the brain. The cochlea perceives vibration transmitted directly from the bones of the head.

Picture:

•*NASA*

Children and noise

THRESHOLDS OF HUMAN HEARING



6

Why is noise sometimes inaudible?

Threshold of hearing is defined as the minimum efficient sonorous pressure (Pa or dB) that can be heard without background noise of a pure tone at a specific frequency (Hz or KHz, cycles per second).

The human audible frequency range is from 20 to 20.000 Hertz (Hz). Frequencies out of this range are not detected by the human ear. The ear is not equally sensitive to all the frequencies.* The most audible frequencies are between 2000 and 3000 Hz (range within which the least pressure is needed to provoke the conscious recognition of a sound). This range can be easily identified where the curve is at its minimum and corresponds to human speaking frequencies.

For this reason, sound meters are usually fitted with a filter whose response to frequency is a bit like that of the human ear. The most widely used sound level filter is the A scale, which roughly corresponds to the inverse of the 40 dB (at 1 kHz) equal-loudness curve. Using this filter, the sound level meter is thus less sensitive to very high and very low frequencies. Measurements made on this scale are expressed as **dBA**.

The "normal threshold" of hearing is defined in "young people with a healthy auditory system".

The **"pain threshold"** is the high level (high dB) audible sound where the level of pressure of the sound produces discomfort or pain. The pressures of the sounds are over the curve: "ultrasounds". Very powerful levels of sound can be perceived by the human ear but cause discomfort and pain.

*Pressures below the audible level are called "infra-sounds": the pressure is detected but our hearing mechanism is not adapted to making the sound evident to the human ear (under the curve in the graphic). These frequencies (less than 20 Hz, not audible for the human ear) can be produced by machines or "ultrasonic" motors of planes. Out of the limits of the human threshold of hearing exists sound that can be perceived by special equipment or animals such as dolphins and bats that are equipped to perceive sound that humans can not perceive. The human being hears a very short portion of the existing sounds, the very weak and the ones above and below of the thresholds are not perceived or they are accompanied by pain, ***<u>and can produce damage to a system that is not prepared to perceive them as the person may not be able to protect her/himself from this deleterious exposure</u>***. There is individual variation within these general parameters.

Reference:

•Noise effects handbook, National Association of Noise Control Officials. *Office of the Scientific Assistant, Office of Noise Abatement and Control, U.S. Environmental Protection Agency*, 1979, revised 1981 (www.nonoise.org/library/handbook/handbook.htm).

Picture:

•*EPA (U.S. Environmental Protection Agency)*

Children and noise

MAGNITUDE AND EFFECTS OF SOUND

COMMON EXAMPLE	dBA	EFFECT
Breathing	0-10	Hearing threshold
Conversation at home	50	Quiet
Freeway traffic (15 m), vacuum cleaner, noisy party	70	**Annoying**, intrusive, interferes with phone use
Average factory, train (at 15 m)	80	**Possible** hearing damage
Jet take-off (at 305 m), motorcycle	100	**Damage** if over 1 minute
Thunderclap, textile loom, chain saw, siren, rock concert	120	Human **pain** threshold
Toy cap pistol, Jet takeoff (at 25 m), firecracker	150	**Eardrum rupture**

7

This abbreviated table correlates common sounds with effects on hearing.

Additional examples for discussion are listed below:

-Quiet suburb or quiet conversation	50 dB A	No significant effect
-Conversation in a busy place, background music or traffic	60 dB A	Intrusive
-Freeway traffic at 15 metres	70 dB A	Annoying
-Average factory, train at 15 metres	80 dB A	Possible hearing damage
-Busy urban street, diesel truck	90 dB A	Chronic hearing damage if exposure over 8 hours
-Subway noise	90 dB A	Chronic hearing damage, speech interfering
-Jet take-off 300 metres	100 dB A	More severe than above
-Stereo held close ear	110 dB A	More severe than above
-Live rock music, jet take off 160 mts	120 dB A	As above, human pain threshold
-Earphones at loud level	130 dB A	More severe than above
-Toy cap pistol, firecracker close ear	150 dB A	Acute damage (eardrum rupture)

dBA weighting curve: response of a filter that is applied to sound level meters to mimic (roughly) the response of human hearing. So a typical human equal loudness curve is somewhat similar to the dBA curve, but inverted.

Reference:

•Children's health and the environment: A review of evidence. Tamburlini G et al., eds. *EEA-WHO*, 2002 (www.eea.europa.eu/publications/environmental_issue_report_2002_29)

SOURCES OF NOISE

Outdoor sources

- Transport
  - Aircraft
  - Road
  - Rail
- Occupational
  - Machinery
- Neighbours
  - Machinery
  - Loud music

Indoor sources

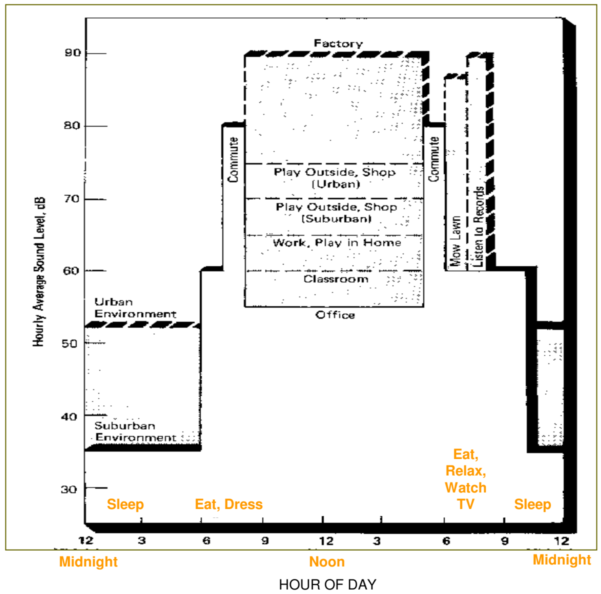
- Ambient noise outside
- Building design and location
- Room acoustics
- Activities of occupants
  - Children

Common sources of outdoor noise arise from transportation (aircraft, car and truck traffic, and trains), occupations (construction machinery, assembly lines), and even from neighbours (yard equipment, loud music). Indoor noise is affected by outdoor noise, and indoor sources such as TV, radio, music and children at play. The level is modified by building design and location as well as room acoustics.

Children and noise

SETTINGS OF NOISE EXPOSURE: "NOISE-SCAPE"

Hypothesized lifestyle noise exposure patterns



EPA

The concept of a "noise-scape" can be useful in thinking about noise exposures. That is, obvious loud noises are imposed upon a background of noises that will vary according to general location (urban vs. rural), time of day (day vs. night) and activity (school vs. play). This image is a schematic representation which illustrates these different aspects of the "noise-scape".

Reference:

•Noise effects handbook, National Association of Noise Control Officials. *Office of the Scientific Assistant, Office of Noise Abatement and Control, U.S. Environmental Protection Agency*, 1979, revised 1981 (www.nonoise.org/library/handbook/handbook.htm).

Picture:

•*EPA (U.S. Environmental Protection Agency)*

Children and noise

NOISE EXPOSURE IN EU

- 40% of population exposed to Leq > 55 dBA during the day
- 20% of population exposed to Leq > 65 dBA during the day
- 30% of population exposed to Lmax > 55 dBA during the night
- Hazard is increasing

Leq: average sound level over the period of the measurement, usually measured A-weighted

Lmax: maximum A-weighted noise level

dBA weighting curve: response of a filter that is applied to sound level meters to mimic (roughly) the response of human hearing. So a typical human equal loudness curve is somewhat similar to the dBA curve, but inverted.

Reference:

•Berglund B et al., eds. Guidelines for Community Noise. Geneva, *WHO*, 1999.

NOISE CONTAMINATION

- Noise exceeding safety threshold is widespread:
  - In neighbourhoods
  - Schools, hospitals and care centres
  - Urban and suburban areas
  - Activities inside the buildings (elevators, water tubs, music in discotheque)
  - From children themselves (toys, equipment, children playing or practicing sports in a close yard)
  - Traffic: heavy road, railways, highways, subways, airports
  - Industrial activities
  - Building and road construction, renovation
- Increased environmental noise levels - more noise sources
- Also linked to population growth

Noise contamination or noise pollution is a concept which implies harmful levels of excess noise. Noise intense enough to cause harm is widely spread.

<<READ SLIDE>>

CONTENTS

VULNERABLE GROUPS OF CHILDREN

- The fetus and babies
- Preterm, low birth weight and small for gestational age babies
- Children with dyslexia and hyperactivity
- Children on ototoxic medication

It is logical to consider certain subgroups of children (since conception) to be particularly at risk for harm from excess noise exposure. These include the fetus, babies and very young infants born preterm, with low birth weight or small for gestational age. Also, children who have learning disabilities or attention difficulties may be more likely to develop early problems with mild hearing loss compared to children without these challenges, and children on ototoxic medications may have higher likelihood of developing problems from exposure to excess noise.

Reference:

•Carvalho WB, et al. Noise level in a pediatric intensive care unit. *J Pediatr* , 2005, 81:495-8.

OBJECTIVES: The purpose of this study was to verify the noise level at a PICU. METHODS: This prospective observational study was performed in a 10 bed PICU at a teaching hospital located in a densely populated district within the city of São Paulo, Brazil. Sound pressure levels (dBA) were measured 24 hours during a 6-day period. Noise recording equipment was placed in the PICU access corridor, nursing station, two open wards with three and five beds, and in isolation rooms. The resulting curves were analyzed. RESULTS: A basal noise level variation between 60 and 70 dBA was identified, with a maximum level of 120 dBA. The most significant noise levels were recorded during the day and were produced by the staff. CONCLUSION: The basal noise level identified exceeds International Noise Council recommendations. Education regarding the effects of noise on human hearing and its relation to stress is the essential basis for the development of a noise reduction program.

VULNERABILITY OF CHILDREN

- Different perception of dangers of noise
  - Can not recognize the dangerous exposures
- Lack of ability to control the environment
  - Are not able to identify and avoid the source of noxious noise
  - Exposure *intra utero*
- Noise can interfere with communication of danger
- May be more exposed due to their behaviour
  - Exploratory or risk behaviour (in children and teenagers)

Special vulnerability of children to noise. The known increased risk is due to

<<READ SLIDE>>

Noise effects in children

"Children may be more prone to the adverse effects of noise because they may be more frequently exposed….and they are more susceptible to the impact of noise". (Tamburlini, 2002)

Reference:

•Children's health and the environment: A review of evidence. Tamburlini G et al., eds. *EEA-WHO*, 2002 (www.eea.europa.eu/publications/environmental_issue_report_2002_29)

Children and noise

VULNERABILITY OF CHILDREN

Why might children be more susceptible to noise effects?

- Possible increased risk due to immaturity
  Increased cochlear susceptibility?
  - *In utero*
  - Animal data studies
- Critical periods in relation to learning
- Lack of developed coping repertoires
- Vulnerable tasks \ Vulnerable settings (schools, home, streets)

What might be the implications of noise effects?

- Lifelong impairment of learning and education
- Short-term deficit followed by adaptation
- Non intentional lesions

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<<READ SLIDE>>

Exposure to excessive noise and vibration during pregnancy may result in high frequency hearing loss in the newborn, may be associated with prematurity and growth retardation, although the scientific evidence remains inconclusive.

The role of the amniotic fluid is not yet defined, nor when and which noises or vibrations can damage the fetal development of the auditory system (e.g. cochlea). Concern about synergism between exposure to noise and ototoxic drugs remains incompletely defined. There are studies on fetal audition dating from 1932 that explore the reaction of the fetus to external noises but even today this remains incompletely characterized.

References:

•Children's health and the environment: A review of evidence, Ed. Tamburlini G. et al*, EEA-WHO, 2002* (www.eea.europa.eu/publications/environmental_issue_report_2002_29).

•National Institute of Public Health Denmark. Health Effects of Noise on Children and Perception of the Risk of Noise. Bistrup ML, ed. *Copenhagen, Denmark: National Institute of Public Health Denmark,* 2001, 29.

CONTENTS

ADVERSE EFFECTS FROM EXCESS NOISE EXPOSURE

- Direct ear damage
  - Noise induced hearing loss
  - Noise induced threshold shift
- Indirect adverse effects
  - Physiological effects
  - Psychological effects
- Impaired cognition

Characteristics of the sound can modify effect

Adverse effects can be divided into direct damage, indirect adverse effects and impaired cognition. Many effects of noise exposure are more thoroughly studied in adults than in children.

The degree of adverse effect is modified by the sound characteristics.

•**Vibration:** can be acute or chronic, audible or inaudible. Vibration can be transmitted to all the body directly through the skin or bones.

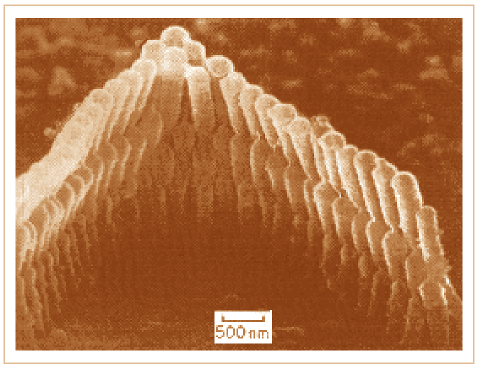
•**Frequencies:** lower and higher (ultra and infra sounds) can also damage the human hearing system, despite being imperceptible, and have important consequences for life (loss of hearing). These consequences can also be present after chronic exposure to low frequency non audible sounds (chronic back noise exposure). Incubators are an example of this exposure.

•**Intensity:** Direct blows to the ears, very loud noise (pneumatic hammer or drill, fire arms, rocket), and sudden but intense sounds can destroy the eardrum and damage the hair cells of the cochlea by bypassing the protective reflexes. Acute trauma can cause a lifelong lesion.

•**Periodicity and Duration***:* Impulse noise is more harmful than continuous because it bypass the natural protective reaction, the damping-out of the ossicles mediated by the facial nerve. Loud noise may result in temporary decrease in the sensitivity of hearing and tinnitus, but repeated exposure may cause these temporary conditions to become permanent.

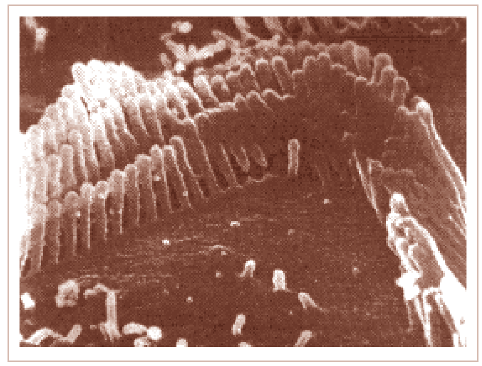
ORGAN DAMAGE
NOISE INDUCED HEARING LOSS

Normal hair cell



VIMM

Noise damaged hair cell



VIMM

Normal healthy “hair cells” transform vibration into nerve impulses sending messages to the brain. Trauma to the hair cells of the cochlea results in hearing loss. Prolonged exposure to sounds louder than 85 dBA is potentially injurious (85 dBA is tolerable for an occupational exposure). Continuous exposure to hazardous levels of noise tend to affect high frequencies regions of the cochlea first. Noise induces hearing loss gradually, imperceptibly, and often painlessly. Often, the problem is not recognized early enough to provide protection. Further, it may not be recognized as a problem, but merely considered a normal consequence of ordinary exposure, and part of the environment and daily life.

References:

•Moeller, Environmental health, *Harvard University Press*, 1992

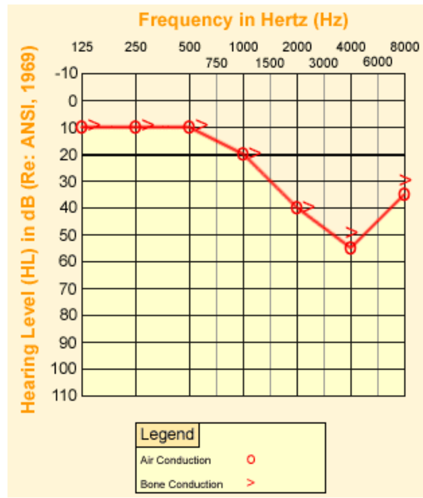
•VIMM (Veterinarian Institute of Molecular Medicine, Italy): www.vimm.it/cochlea/cochleapages/theory/hcells/hcells.htm

Pictures:

•VIMM (Veterinarian Institute of Molecular Medicine, Italy): www.vimm.it/cochlea/cochleapages/theory/hcells/hcells.htm - used with copyright permission.

AUDIOGRAM

Noise-induced
hearing loss



OSHA

<< NOTE TO USER: If possible place an audiogram of a child living in your local environment here to illustrate either normal hearing, or hearing damaged by environmental noise. >>

Noise-induced hearing loss is insidious, but increases with time, usually beginning in adolescent years. As shown here, it affects the high frequencies first. The speech window is between 500 and 4000 Hz, so it is not surprising that high frequency loss of large magnitude could go undetected for long periods of time without formal testing.

Picture:

- *OSHA (U.S. Department of Labor Occupational Safety & Health Administration) www.osha.gov/dts/osta/otm/noise/images/sensorineural_loss_audiogram.gif*

CHILDREN AND NOISE: SETTINGS

Noise at home	50 - 80 dB A
Home appliances	78 - 102 dB A
Noise in incubators	60 - 75 dB A, peak sounds 120 dB A
Noise in hospitals	> 70 dB A
Day-care institutions	75 – 81 dB A
Noise from toys peak sounds	79 - 140 dB A
Background noise in schools	46.5 – 77.3 dB A

These ranges represent excessive everyday exposures of children to sound.

References:

•Committee on Environmental Health. Noise: A Hazard for the Fetus and Newborn. *Pediatrics,* 1997, 100:724-27.

•Etzel RA, ed. Pediatric Environmental Health. 2nd ed. American Academy of Pediatrics Committee on Environmental Health.; *Elk Grove Village, IL: American Academy of Pediatrics,* 2003.

NOISE INDUCED THRESHOLD SHIFT (NITS)

- Initially - a temporary condition
  - Decrease in sensitivity to noise
  - Tinnitus
- Caused by exposure to loud noises
- May be reversible or irreversible
  - Severity and duration of exposure
  - Continuous and recurrent exposure

Exposure to loud noise may result in a temporary decrease in the sensitivity of hearing and tinnitus. This condition, called temporary noise-induced threshold shift (NITS), lasts for several hours depending on the degree of exposure, and may become permanent depending on the severity and duration of noise exposure. Noise induced threshold shifts may be reversible; however, continued excessive noise exposure could lead to progression of NITS to include other frequencies and lead to increase severity and permanent hearing loss. The consequences of these measured NITS may be enormous if they progress to a persistent minimal sensorineural hearing loss. In school-aged children, minimal sensorineural hearing loss has been associated with poor school performance and social and emotional dysfunction.

Children and noise

DIRECT DAMAGE

PREVALENCE NOISE INDUCED THRESHOLD SHIFTS

National survey US children (n=5249)

Characteristics	%	(95% CI)
Age: 6-11 years old	8.5	(6.9-10.0)
12-19 years old	15.5	(13.3-17.6)
Sex: Male	14.8	(12.3-17.3)
Female	10.1	(8.3-11.8)
Urban status: Metropolitan	11.9	(9.8-14.0)
Non-metropolitan	13.0	(11.3-14.6)

Niskar AS, Pediatrics, 2001, 108(1):40-3

22

This is evidence that children are experiencing changes in hearing which are consistent with excess noise exposure. These data show the prevalence of Noise Induced Threshold Shift (NITS) in children which increases with age. The prevalence of NITS in one or both ears among children 6-19 year of age in the USA was recently found to be 12.5% (or 5.2 million) children affected. Most children with NITS have an early phase of NITS in only one ear and involving only a single frequency, however among children with NITS, 4.9% had moderate to profound NITS. This table demonstrates several points. First, older children have a higher prevalence of NITS compared to younger children suggesting that ongoing exposure to excess noise in the environment may be causing cumulative hearing damage. Boys in this survey were more likely to have evidence of excess noise exposure measured as NITS compared to girls, but there was little difference between urban and non-urban status.

Reference:

•Niskar AS. Estimated prevalence of noise-induced hearing threshold shifts among children 6 to 19 years of age: the Third National Health and Nutrition Examination Survey, 1988-1994, United States. *Pediatrics,* 2001, 108(1):40-3

This analysis estimates the first nationally representative prevalence of noise-induced hearing threshold shifts (NITS) among US children. Historically, NITS has not been considered a common cause of childhood hearing problems. Among children, NITS can be a progressive problem with continued exposure to excessive noise, which can lead to high-frequency sound discrimination difficulties (eg, speech consonants and whistles). The Third National Health and Nutrition Examination Survey (NHANES III) was conducted from 1988 to 1994. NHANES III is a national population-based cross-sectional survey with a household interview, audiometric testing at 0.5 to 8 kHz, and compliance testing. A total of 5249 children aged 6 to 19 years completed audiometry and compliance testing for both ears in NHANES III. The criteria used to assess NITS included audiometry indicating a noise notch in at least 1 ear. RESULTS: Of US children 6 to 19 years old, 12.5% (approximately 5.2 million) are estimated to have NITS in 1 or both ears. In the majority of the children meeting NITS criteria, only 1 ear and only 1 frequency are affected. In this analysis, all children identified with NITS passed compliance testing, which essentially rules out middle ear disorders such as conductive hearing loss. The prevalence estimate of NITS differed by sociodemographics, including age and sex. CONCLUSIONS: These findings suggest that children are being exposed to excessive amounts of hazardous levels of noise, and children's hearing is vulnerable to these exposures. These data support the need for research on appropriate hearing conservation methods and for NITS screening programs among school-aged children. Public health interventions such as education, training, audiometric testing, exposure assessment, hearing protection, and noise control when feasible are all components of occupational hearing conservation that could be adapted to children's needs with children-specific research.

INDIRECT ADVERSE EFFECTS

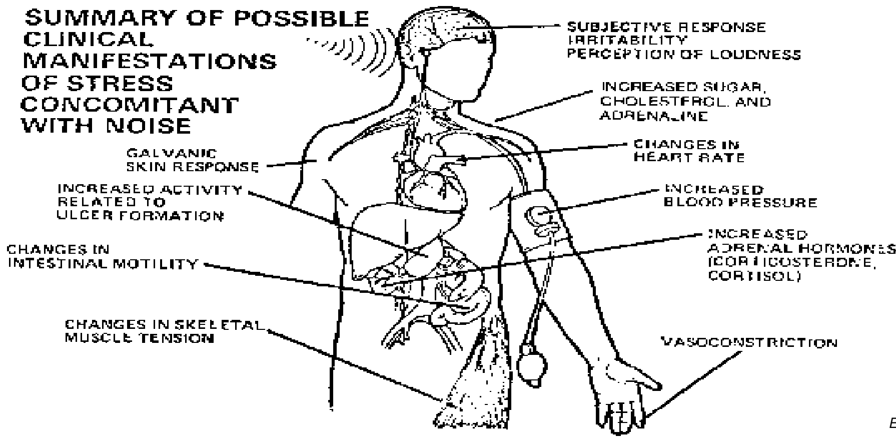
- ❖ Stress-related somatic effects
  - Stress hormone
  - Blood pressure
  - Muscle spasm
- ❖ Psychological effects
  - Annoyance / Isolation
  - Sleep disturbance
  - Mental health
- ❖ Cognitive effects
  - Reading, concentration, memory, attention

The next section will review the indirect adverse effects of noise listed here.

Children and noise

INDIRECT DAMAGE

PHYSIOLOGICAL EFFECTS OF NOISE



EPA

There might be harmful consequences to health during the state of alertness as well as when the body is unaware or asleep.

24

There are a variety of physiological effects that have been documented or postulated as a result of excess noise exposure.

<<READ SLIDE>>

References:

Stress response:

•Frankenhaeuser M. Immediate and delayed effects of noise on performance and arousal. *Biol Psychol,* 1974, 2:127-33

Increased excretion of adrenaline and noradrenaline demonstrated in humans exposed to noise at 90 dBA for 30 minutes.

•Henkin RI. Effect of sound on the hypothalamic-pituitary-adrenal axis. *Am J. Physiol,* 1963, 204:710-14

Hypothalamic- pituitary- adrenal axis is sensitive to noise as low as 65 dBA (53% increase in plasma 17 HO corticosteroid levels).

•Rosenberg J. Jets over Labrador and Quebec: noise effects on human health. *Can. Med. Assoc. J.,* 1991, 144(7):869-75.

Biochemical evidence of the stress response was found in elevated urinary cortisol and hypertension accompanied a 30 minute exposure to 100dBA in 60 children aged 11 to 16 years.

Sleep derivation:

Noise levels at 40-50 dBA result in 10-20% increase in awakening or EEG changes

•Falk SA. Hospital noise levels and potential health hazards. *Engl. J Med.,* 1973, 289(15):774-81

•Hilton BA. Quantity and quality of patient's sleep and sleep-disturbing factors in respiratory intensive care unit, *J Adv Nurs,* 1976, 1(6):453-68

•Thiessen GJ. Disturbance of sleep by noise. *J. Acoustic Soc. Am.,* 1978, 64(1):216-22

Cardiovascular effects:

•Etzel RA, ed. *Pediatric Environmental Health.* 2nd ed. American Academy of Pediatrics Committee on Environmental Health. Elk Grove Village, IL: American Academy of Pediatrics; 2003.

Exposure to noise levels greater than 70 dBA causes increases in vasoconstriction, heart rate and blood pressure

Picture:

•*EPA (U.S. Environmental Protection Agency)*

Children and noise

INDIRECT DAMAGE

STRESS HORMONES - CHILDREN

Noise type (leq)	Noise exposure	N°	Adrenaline	Noradrenaline	Cortisol	Author
Aircraft	53, 62	217	+	+	+	Evans, 1998
Aircraft	56, 70	40	0	0	0	Ising, 1999
Road, Rail	<50, >60	115	0	0	+	Evans, 2001
Road	30-54, 55-78	56			+	Ising, 2001
Aircraft	<57, >66	238			0	Stansfeld, 2001
Aircraft	53, 62	204	0	0	0	Haines, 2001

+ increase with noise, - decrease with noise, 0 no effect

Adapted from Babisch W, Noise Health, 2003, 5(18):1-11

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In experimental studies with humans carried out in the laboratory, unequivocal findings of noise exposure on the endocrine system have been sometimes observed. However, exposure conditions vary considerably between experiments. Furthermore, secretory patterns of hormone excretion vary between individuals. It is not clear as to what extent findings from experimental studies on endocrine responses of noise reflect a potential health hazard. To more completely characterize these indirect adverse effects of excess noise, there is a need to 1) develop a consensus on measurement techniques, 2) replicate results of adult studies in children, and 3) link hormone levels to health impairment. When it is done, stress hormone responses may identify risk groups.

Leq: average sound level over the period of the measurement, usually measured A-weighted

N°: number of subjects

Reference:

•Babisch W. Stress hormones in the research on cardiovascular effects of noise. *Noise Health*, 2003, 5(18):1-11

In recent years, the measurement of stress hormones including adrenaline, noradrenaline and cortisol has been widely used to study the possible increase in cardiovascular risk of noise exposed subjects. Since endocrine changes manifesting in physiological disorders come first in the chain of cause-effect for perceived noise stress, noise effects in stress hormones may therefore be detected in populations after relatively short periods of noise exposure. This makes stress hormones a useful stress indicator, but regarding a risk assessment, the interpretation of endocrine noise effects is often a qualitative one rather than a quantitative one. Stress hormones can be used in noise studies to study mechanisms of physiological reactions to noise and to identify vulnerable groups. A review is given about findings in stress hormones from laboratory, occupational and environmental studies.

Children and noise

INDIRECT DAMAGE

BLOOD PRESSURE - AIRCRAFT NOISE

Study	Psys (mmHg)	Pdia (mmHg)	Sound level (Leq)
Karagodina, 1969	abnormalities	abnormalities	distance from airport
Cohen, 1980	3-7	3-4	<70 dBA (indoors)
Cohen, 1981	no effect	no effect	70 dBA (indoors)
Evans, 1995	2	0	68 dBA (outdoors)
Evans, 1998	3	3	64 dBA (outdoors)
Morrell, 1998	negative	negative	ANEI 45 (outdoors)
Morrell, 2000	no effect	negative	ANEI 45 (outdoors)

- ❖ Inconsistent picture: 3 positive, 4 negative studies
- ❖ Prospective studies: 1 positive, 1 negative study
- ❖ Magnitude of effect found in positive studies may be relevant

Studies on elevated blood pressure and noise exposure (from aircraft) are also inconsistent. Only the cross-sectional study of Cohen shows that aircraft noise exposure (specifically at school) is statistically significantly associated with increases in systolic and diastolic blood pressure.

Leq: average sound level over the period of the measurement, usually measured A-weighted

Psys: systolic pressure

Pdia: diastolic pressure

dBA weighting curve: response of a filter that is applied to sound level meters to mimic (roughly) the response of human hearing.

So a typical human equal loudness curve is somewhat similar to the dBA curve, but inverted.

ANEI: Australian Noise Exposure Index.

References:

Aircraft Noise:

•Cohen S. Physiological, motivational and cognitive effects of aircraft noise on children: moving from the laboratory to the field*. Am Psychol.*, 1980, 35:231-43.

•Cohen S. Aircraft noise and children: longitudinal and cross-sectional evidence on adaptation to noise and the effectiveness of noise abatement. *J. Pers Soc Psychol.*, 1981, 40:331-45

•Evans G. Chronic noise and psychological stress. *Psychological Science,* 1995, 6:333-38

•Evans G. Chronic noise exposure and physiological response: a prospective study of children living under environmental stress. *Psychological Science*, 1998, 9:75-77

•Karagodina IL. Effect of aircraft noise on the population near airports. *Hygiene and Sanitation*, 1969, 34:182-187

•Morrell S. Cross-sectional relationship between blood pressure of school children and aircraft noise. In N.L. Carter, & R.F.S Job (Eds.), Noise Effects. *Proceedings of the 7th International on Noise as a Public Health Problem. Sydney, Australia: Noise Effects Inc*, 1998, 275-79.

•Morrell S. Cross sectional and longitudinal results of a follow up examination of child blood pressure and aircraft noise. *The Inner Sydney Child Blood Pressure Study. Proceedings Internoise, SFA, Nice, France*, 2000, 4:2071.

•van Kempen E. et al. Noise exposure and children's blood pressure and heart rate: the RANCH project. *Occup Environ Med.,* 2006, 63:632-39

BACKGROUND: Conclusions that can be drawn from earlier studies on noise and children's blood pressure are limited due to inconsistent results, methodological problems, and the focus on school noise exposure. OBJECTIVES: To investigate the effects of aircraft and road traffic noise exposure on children's blood pressure and heart rate. METHODS: Participants were 1283 children (age 9-11 years) attending 62 primary schools around two European airports. Data were pooled and analysed using multilevel modelling. Adjustments were made for a range of socioeconomic and lifestyle factors. RESULTS: After pooling the data, aircraft noise exposure at school was related to a statistically non-significant increase in blood pressure and heart rate. Aircraft noise exposure at home was related to a statistically significant increase in blood pressure. Aircraft noise exposure during the night at home was positively and significantly associated with blood pressure. The findings differed between the Dutch and British samples. Negative associations were found between road traffic noise exposure and blood pressure, which cannot be explained. CONCLUSION: On the basis of this study and previous scientific literature, no unequivocal conclusions can be drawn about the relationship between community noise and children's blood pressure.

Traffic Noise:

•Babisch W. Blood pressure of 8-14 year old children in relation to traffic noise at home--results of the German Environmental Survey for Children (GerES IV). *The Science of the total environment*, 2009, 407(22):5839-43.

•Babisch W, Kamp I. Exposure-response relationship of the association between aircraft noise and the risk of hypertension. *Noise Health.* 2009 Jul-Sep, 11(44):161-8.

•Belojevic G et al. Urban road-traffic noise and blood pressure and heart rate in preschool children. *Environ Int.* 2008, 34(2):226-31. Epub 2007 Sep 14.

Children and noise INDIRECT DAMAGE

HYPERTENSION AND EXPOSURE TO NOISE NEAR AIRPORTS
The HyENA study

Results

- ❖Significant exposure-response relationship
- ❖Night time aircraft noise exposure: borderline significant relationship
- ❖Risk of myocardial infarction in relation to noise exposure: analysis ongoing
- ❖Effects of noise exposure on stress hormone level (cortisol): statistical analyses and epidemiological ongoing

Conclusion

- ❖ Prevalence of hypertension increased with increasing noise exposure
- ❖ Long-term road traffic noise exposure effects on BP
- ❖ Acute effect on hypertension of night-time aircraft noise
- ❖ Highly annoyed people are found at aircraft noise levels

An increasing number of people live near airports with considerable noise and air pollution. The Hypertension and Exposure to Noise near Airports (HYENA) project aims to assess the impact of airport-related noise exposure on blood pressure (BP) and cardiovascular disease using a cross-sectional study design.

Although the study has been made in adults (men and women between 45-70 years old), it might be a good cardiovascular disease predictor in children.

Reference:

•Jarup L. Hypertension and Exposure to Noise near Airports (HYENA): Study Design and Noise Exposure Assessment. *Environ Health Perspect.,* 2005, 113(11):1473–1478.

Children and noise

INDIRECT DAMAGE

PSYCHOLOGICAL DAMAGE

- Exposure to **moderate level of noise** can cause
  - Psychological stress
  - Annoyance, interference with activity, isolation
  - Headache, tiredness and irritability; may impair intellectual function and performance of complex tasks
- Exposure to **intense level of noise** can
  - Cause personality changes and aggressive/violent reactions
  - Reduce ability to cope
  - Alter work performance and intellectual function
  - May cause muscle spasm and also break a bone (when combined with strong vibration)
  - Sleep disturbance
  - Changes in mental health.
- Exposure to **sudden, unexpected noise** can cause
  - Startle reaction with stress responses
  - Cause non intentional injuries

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Psychological effects correlate with intensity (or loudness) of the noise.

Exposure to **moderate levels of noise** can cause psychological stress.

Other effects can be:

• Annoyance (fear, anger, feeling bothered, feelings of being involuntarily and unavoidably harmed, and feelings of having privacy invaded), interference with activity.

•Headache, tiredness and irritability are also common reactions to noise.

•Possible impairment of intellectual function and performance of complex tasks. Depends on the nature of sound and individual tolerance.

Exposure to **intense level of noise** can:

• Cause personality changes and provoke aggressive and violent reactions.

• Reduce ability to cope.

• Alter work performance and intellectual function.

• Cause muscle spasm and also break a bone (when combined with strong vibration).

• Cause sleep disturbance.

• Provoke changes in mental health.

Exposure to **sudden, unexpected noise** can cause:

• Startle reaction with stress responses.

•Cause non intentional injuries.

Stress response consisting in acute terror and panic was described in children upon exposure to sonic booms.

References:

•Kam PC. Noise pollution in the anaesthetic and intensive care environment. *Anaesthesia*, 1994, 49(11):982-6

•Kujala T, Brattico E. Detrimental noise effects on brain's speech functions. *Biol Psychol.* 2009, 81(3):135-43. Epub 2009 Apr 8.

•Rosenberg J. Jets over Labrador and Quebec: noise effects on human health. *Can. Med. Assoc. J.*, 1991, 144(7):869-75

Children and noise

INDIRECT DAMAGE

IMPAIRED COGNITIVE FUNCTION

- Chronic noise exposure impairs cognitive function
  - Reading comprehension
  - Long term memory
- Dose-response relationships
  - Supported by both laboratory and field studies
- Study of possible mechanisms and noise reduction interventions
  - Tuning out of attention / concentration
  - Impairment of auditory discrimination

The most robust area of study on noise and effects in children comes from studies which evaluate the effect of noise on learning and cognitive function; there are possible mechanisms, including noise-related changes in attention or distraction and impaired auditory discrimination.

<<READ SLIDE>>

Children and noise IMPAIRED COGNITION

ENVIRONMENTAL NOISE AND COGNITIVE DEVELOPMENT IN PRESCHOOL CHILDREN

- Children 6 months - 5 years
- Inverse associations between noise level at home and cognitive development

Wachs TD. Early Experience and Human Development. New York Plenum, 1982
Evans GW. Children's Environments,1993,10(1):31-51

Effects of noise on cognitive development have been documented in preschool ages as well. Higher levels of noise at home are associated with decrements in cognitive development for age.

References:

•Evans GW. Non-auditory effects of noise on children: A critical review*. Children's Environments,* 1993,10(1):31-51.

•Maxwell LE et al. The effects of noise on pre-school children's pre-reading skills. *Journal of Environmental Psychology*, 2000, 20(1):91-97.

•Wachs TD. Early Experience and Human Development. *New York Plenum,* 1982.

•Yang W, Bradley JS. Effects of room acoustics on the intelligibility of speech in classrooms for young children. *J Acoust Soc Am*. 2009, 125(2):922-33.

Children and noise

IMPAIRED COGNITION

APARTMENT NOISE AND READING ABILITY

- 54 children living in apartments above interstate highway
  - 32nd floor: 55 dBA,
  - 20th floor: 60 dBA,
  - 8th floor: 66 dBA
- Measures of auditory discrimination and reading ability
- Correlations between floor level and auditory discrimination vary by duration of residence
- **Floor level correlates with reading-abolished by adjustment for auditory discrimination**
- Reading powerfully associated with mothers' education

Cohen S. Journal of Experimental and Social Psychology, 1973, 9:407-22.

This study shows that street traffic noise measured on different floors of a multilevel apartment correlates inversely with auditory discrimination and reading ability. The higher floors were quieter and children scored better on reading ability and auditory discrimination. Correlations varied with duration of residence, and when reading level scores were adjusted for auditory discrimination measures, the floor level effect disappeared. Reading is also powerfully associated with mother's education.

Reference:

•Cohen S. Apartment noise, auditory discrimination, and reading ability in children. *Journal of Experimental and Social Psychology*, 1973, 9:407-22.

Children and noise

IMPAIRED COGNITION

RAILWAY NOISE AND READING SCORES

- Reading scores compared between classes in same school
- Exposed/not exposed to railway noise
- No selection of children into classes
- **Poorer performance on achievement test on noisy side**
- Measuring reading age 3-4 months behind on noisy side

Bronzaft AL. Environment and Behavior, 1975, 7:517-28

32

This study compared reading scores between classrooms in the same school that were exposed and not exposed to railway noise. Poorer performance was noted on the noisy side with a 3-4 month delay compared to the quieter side. There was no selection of the children in each class. This is supportive evidence that noise impaired reading learning.

Reference:

•Bronzaft AL. The effect of elevated train noise on reading ability. *Environment and Behavior.* 1975, 7:517-28.

Children and noise IMPAIRED COGNITION

IMPAIRED COGNITIVE FUNCTION

- **Los Angeles airport study**
  Cohen S. Am Psychol., 1980, 35:231-43.
- **New York airport city**
  Evans G. Environment and Behavior, 1997, 29(5):638-656.
- **Munich airport study**
  Evans G. Psychological Science, 1998, 9:75-77; Psychological Science, 1995,6:333-38
- **Heathrow studies**
  Haines MM. Psychological Medicine, 2001a,b,c; J Epidemiol Community Health, 2002, 56(2):139

Over 20 studies have reported that noise **adversely affects** children's academic performance

Many studies have reported that noise can adversely affect children's academic performance. Transport noise is well-studied. Some of the most important studies are the Los Angeles airport study, the New York airport study, the Munich and Heathrow studies.

References:

•Cohen S. Physiological, motivational and cognitive effects of aircraft noise on children: moving from the laboratory to the field. *Am Psychol.*, 1980, 35:231-43.

•Cohen S. Aircraft noise and children: longitudinal and cross-sectional evidence on adaptation to noise and the effectiveness of noise abatement. *J. Pers Soc Psychol.*, 1981, 40:331-45

•Evans G. Chronic noise and psychological stress. *Psychological Science,* 1995, 6:333-38

•Evans G. Chronic noise exposure and physiological response: a prospective study of children living under environmental stress. *Psychological Science,* 1998, 9:75-77

•Evans G. Chronic noise exposure and reading deficits: The mediating effects of language acquisition. *Environment and Behavior*, 1997, 29(5):638-656.

•Haines MM. Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychological Medicine*, 2001a, 31:265-77.

•Haines MM. The West London Schools Study: the effects of chronic aircraft noise exposure on child health. *Psychological Medicine*, 2001b, 31:1385-96.

•Haines MM. A follow-up study of effects of chronic noise exposure on child stress responses and cognition. *International Journal of Epidemiology*, 2001c, 30:839-45.

•Haines MM. Multilevel modelling of aircraft noise on performance tests in schools around Heathrow Airport London. *J Epidemiol Community Health*, 2002, 56(2):139-44

•Ristovska G. et al. Psychosocial effects of community noise: cross sectional study of school children in urban center of Skopje, Macedonia. *Croat Med J.* 2004, 45(4):473-6.

AIM: To assess noise exposure in school children in urban center in different residential areas and to examine psychosocial effects of chronic noise exposure in school children, taking into account their socioeconomic status. METHODS: We measured community noise on specific measurement points in residential-administrative-market area and suburban residential area. We determined the average energy-equivalent sound level for 8 hours (LAeq, 8 h) or 16 hours (LAeq, 16 h) and compared measured noise levels with World Health Organization (WHO) guidelines. Psychological effects were examined in two groups of children: children exposed to noise level LAeq, 8 h >55 dBA (n=266) and children exposed to noise level LAeq, 8 h <55 dBA (n=263). The examinees were schoolchildren of 10-11 years of age. We used a self-reported questionnaire for each child - Anxiety test (General Anxiety Scale) and Attention Deficit Disorder Questionnaire intended for teachers to rate children's behavior. We used Mann Whitney U test and multiple regression for identifying the significance of differences between the two study groups. RESULTS: School children who lived and studied in the residential-administrative-market area were exposed to noise levels above WHO guidelines (55 dBA), and school children who lived and studied in the suburban residential area were exposed to noise levels below WHO guidelines. Children exposed to LAeq, 8 h >55 dBA had significantly decreased attention (Z=-2.16; p=0.031), decreased social adaptability (Z =-2.16; p=0.029), and increased opposing behavior in their relations to other people (Z=-3; p=0.001). We did not find any correlation between socioeconomic characteristics and development of psychosocial effects. CONCLUSION: School children exposed to elevated noise level had significantly decreased attention, and social adaptability, and increased opposing behavior in comparison with school children who were not exposed to elevated noise levels. Chronic noise exposure is associated with psychosocial effects in school children and should be taken as an important factor in assessing the psychological welfare of the children.

•Stansfeld SA. Aircraft and road traffic noise and children's cognition and health: a cross-national study. *Lancet,* 2005, 365: 1942–49.

•van Kempen EE et al. Children's annoyance reactions to aircraft and road traffic noise. *J Acoust Soc Am.* 2009, 125(2):895-904.

Children and noise **IMPAIRED COGNITION**

MUNICH AIRPORT
SCHOOL PERFORMANCE

- Closure of old airport, opening of new airport
- **Deficits in long-term memory and reading around old airport**
- **Impairments diminish within 2 years after airport closed**
- **Same impairments develop in new group of children within 2 years of new airport opening**

US Transportation Security Administration

Hygge S, Psychol Sci. (2002)13(5):469

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When an old airport was closed down in Munich, deficits in long term memory and reading in children exposed to the old airport improved within 2 years of the airport's closure and the associated decreased noise exposure. Interestingly, the children exposed to noise from the new airport replacing the old began to have the same deficits in long term memory and reading that were seen in the children exposed to the old airport—also within 2 years.

Reference:

•Hygge S. et al. A prospective study of some effects of aircraft noise on cognitive performance in schoolchildren, *Psychol Sci.,* 2002, 13(5):469.

Before the opening of the new Munich International Airport and the termination of the old airport, children near both sites were recruited into aircraft-noise groups (aircraft noise at present or pending) and control groups with no aircraft noise (closely matched for socioeconomic status). A total of 326 children (mean age = 10.4 years) took part in three data-collection waves, one before and two after the switch-over of the airports. After the switch, long-term memory and reading were impaired in the noise group at the new airport. and improved in the formerly noise-exposed group at the old airport. Short-term memory also improved in the latter group after the old airport was closed. At the new airport, speech perception was impaired in the newly noise-exposed group. Mediational analyses suggest that poorer reading was not mediated by speech perception, and that impaired recall was in part mediated by reading.

Picture:

•*US Transportation Security Administration*

Children and noise

IMPAIRED COGNITION

STRENGTH OF EVIDENCE FOR EFFECTS OF AIRCRAFT NOISE ON CHILDREN

HEALTH OUTCOME	STRENGTH OF EVIDENCE
Annoyance	Sufficient
Hearing loss	Sufficient
Cognitive performance - **reading**	Sufficient
Cognitive performance - **memory**	Sufficient
Cognitive performance - **auditory discrimination**	Sufficient
Cognitive performance - **speech perception**	Sufficient
Cognitive performance - **academic performance**	Sufficient
Cognitive performance - **attention**	Inconclusive
Motivation	Sufficient / limited
Wellbeing/perceived stress	Sufficient / limited
Catecholamine secretion	Limited / inconclusive
Hypertension	Limited (weak associations)
Psychiatric disorder	Inconclusive / no effect
Sleep disturbance	Inadequate / no effect
Birth weight	Inadequate
Immune effects	Inadequate

Here is a brief summary slide examining the weight of the evidence for health outcomes in children from aircraft noise. We are indebted to Dr. Stephen Stansfeld (Queen Mary, University of London) for kindly lending us this and many of the previous slides for this project. This slide highlights the clear associations in children between annoyance, hearing loss and impaired cognitive performance and excess noise. The lower categories are still in need of investigation.

<<READ SLIDE>>

CONTENTS

EFFECTS OF NOISE BY AGE-GROUP

- Fetus
- Infant
- Pre-school, school-aged children
- Teenager
- Youth

EFFECTS OF NOISE ON THE FETUS

- Growth retardation
  - Occupational exposure of the mother to noise
  - Environmental noise unlikely to cause effects, but exposure to chronic low-dose noise requires more study
- Hearing impairment
  - Possible effects

There are several paediatric populations which may be at increased risk of harm from noise. The fetus is one in which there is some evidence that occupational exposure to a pregnant woman may result in growth retardation and/or hearing impairment. Little is known about the effects of non-occupational noise on fetal development, and further studies are needed.

Reference:

•American Academy of Paediatrics, Committee on Environmental Health. Noise: a hazard to the fetus and newborn. *Pediatrics*. 1997, 100:724-727.

EFFECTS OF NOISE ON INFANTS

Pre-term and full-term baby

- Exposed to “Neonatal Intensive Care Unit" (NICU) noise
  - Pre-term babies have immature hearing organs / systems
- Adverse noise-induced effects on the pre-term baby
  - **Hearing impairment:** possible effect
  - **Sleep disturbances**: awakening, sleep disruption
  - **Others**: crying

Babies who are born pre-term or require intensive care in hospital are exposed to large amounts of noise from incubators and busy hospital settings. Furthermore, this noise may be continuous, 24 hours/day.

They are exposed to “Neonatal Intensive Care Unit" (NICU) noise (60 - 90 dBA max. 120 dBA) and noise inside the incubators (60 – 75 dBA max. 100 dBA). Pre-term babies must cope with their environment with immature organ systems (auditory, visual and central nervous system). These last stages of maturation occur, in part, during the time the pre-term child is in an incubator or neonatal intensive care unit (NICU).

References:

•Brandon DH. Effect of Environmental Changes on Noise in the NICU. *Advances in Neonatal Care*, 2008, 8(5):S5-S10

•Milette IH, Carnevale FA. I'm trying to heal...noise levels in a pediatric intensive care unit. *Dynamics,* 2003, 14:14-21.

The literature demonstrates clearly that most intensive care units exceed the standard recommendations for noise levels in hospitals, and that high noise levels have negative impacts on patients and staff. The purpose of this study was to evaluate the level of noise in a PICU and compare it to the recommendations of ternational bodies. We outline recommendations to promote the awareness of this problem and suggest strategies to decrease the level of noise in a PICU. The orientations of these strategies are threefold: 1) architectural-acoustic design, 2) equipment design and, most importantly, 3) staff education.

Children and noise

EFFECTS OF NOISE
IN PRE-SCHOOL AND SCHOOL-AGED CHILDREN

- Hearing impairment
  - In isolated cases by toys or equipment
- Sleep disturbances
  - Earlier responses than adults (EEG awakenings)
- Somatic effects
  - Blood pressure and stress hormones
- Psycho-social effects
  - No studies on behaviour with high environmental noise levels
  - Cognitive tasks are impaired, like reading, long term memory, attention and motivation
- Vocal nodule

EEG: electroencephalogram

<<READ SLIDE>>

Children raise their voices and risk developing hoarseness and vocal nodules because of noise and relative overcrowding. The number of children screaming so much and so loudly that their voices are damaged and require treatment increased in Denmark during the 1990s. Noise in schools and day care institutions results in boys' voices getting hoarse and girls' voices squeaky. Children with vocal nodules can be difficult to understand and risk losing their voices altogether. Other children become so tired of screaming or of trying to make themselves heard that they give up saying anything at all and, for example, do not raise their hands in class. If children give up speaking, their voices do not develop properly and language learning is not reinforced.

References:

•Boman, E. The effects of noise and gender on children's episodic and semantic memory. *Scandinavian Journal of Psychology, 2004, 45*:407 –416.

•Bowen C. *Vocal nodules and voice strain in pre-adolescents*. 1997 (members.tripod.com/Caroline_Bowen/teen-nodules.htm, accessed November 2009).

•Clark C et al. Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: the RANCH project. *Am J Epidemiol*. 2006, 163:27-37.

Transport noise is an increasingly prominent feature of the urban environment, making noise pollution an important environmental public health issue. This paper reports on the 2001-2003 RANCH project, the first cross-national epidemiologic study known to examine exposure-effect relations between aircraft and road traffic noise exposure and reading comprehension. Participants were 2,010 children aged 9-10 years from 89 schools around Amsterdam Schiphol, Madrid Barajas, and London Heathrow airports. Data from The Netherlands, Spain, and the United Kingdom were pooled and analyzed using multilevel modeling. Aircraft noise exposure at school was linearly associated with impaired reading comprehension; the association was maintained after adjustment for socioeconomic variables (beta = -0.008, p = 0.012), aircraft noise annoyance, and other cognitive abilities (episodic memory, working memory, and sustained attention). Aircraft noise exposure at home was highly correlated with aircraft noise exposure at school and demonstrated a similar linear association with impaired reading comprehension. Road traffic noise exposure at school was not associated with reading comprehension in either the absence or the presence of aircraft noise (beta = 0.003, p = 0.509; beta = 0.002, p = 0.540, respectively). Findings were consistent across the three countries, which varied with respect to a range of socioeconomic and environmental variables, thus offering robust evidence of a direct exposure-effect relation between aircraft noise and reading comprehension.

•Jessen B, Ruge G. Skolebørn skriger sig syge [Schoolchildren scream until they get sick]. *Berlingske Tidende,* 2000:26.

Children and noise

EFFECTS OF NOISE….
A WORD APART FOR TEENAGERS!!

- Potential sources of hearing impairment
  - Noisy toys, firecrackers, boom-cars, musical instruments, others
- Discotheques and pop concerts
  - Exposure similar to occupational exposures
  - Use of music headphones
- Loss of hearing may go undetected for many years after chronic exposure to high levels of noise
- Increased rates of adolescent hearing impairment in last 3 decades
- Protection needed from the start
  - Be instructed to use personal hearing protection
  - Not only at work but also at technical and polytechnic schools

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<<READ SLIDE>>

Noise is associated with youth. Often, teenagers' exposure is constant. Prolonged exposure can lead to a transitory loss of 10-30 dB for several minutes after the noise ceases. Frequency of exposure, personal variability, and age of exposure determine the pattern of the damage.

Music occurs outside of the major frequencies of the human voice and over exposure to loud music causes loss of discrimination at low frequencies which may not be detected without formal testing for years. “Walkman” equipment is designed for emissions not higher than 80 dB, but the combination of an immature hearing system and a prolonged use may cause cumulative damage. Technology can be modified to bypass factory-imposed limitations and result in very loud music/noise exposure. Loss of concentration because of the focus on the music, in the presence of a potentially dangerous situation, makes a young person more vulnerable to accidents.

Teenagers should be instructed to use personal hearing protection as soon as they start being exposed to high noise levels, not only at work, but also at technical and polytechnic schools. If noise-abatement measures are not taken, good hearing will not be preserved and noise-induced tinnitus will not be prevented. The extent of hearing impairment in teenagers, caused by occupational noise exposure, and exposure at technical and polytechnic schools is unknown.

There are insufficient numbers of studies on somatic, psycho-social and behavioural effects of noise in teenagers.

References:

•Axelsson A. et al. Early noise-induced hearing loss in teenage boys. *Scand Audiol,* 1981:10: 91–96.

•Baig LA. et al. Health and safety measures available for young labourers in the cottage industries of Karachi. *J Coll Physicians Surg Pak, 2005, 15:380.*

•Fontana AM. et al. Brazilian young adults and noise: Attitudes, habits, and audiological characteristics. *International Journal of Audiology*, 2009, 48(10):692-699

•Plontke SK et al. The incidence of acoustic trauma due to New Year's firecrackers*. Eur Arch Otorhinolaryngol,* 2002, 259:247-52*.*

•Ryberg JB. A national project to evaluate and reduce high sound pressure levels from music. *Noise Health,* 2009, 11(43):124-8.

•Segal S. et al. Inner ear damage in children due to noise exposure from toy cap pistols and firecrackers: a retrospective review of 53 cases. *Noise Health,* 2003, 5:13-8*.*

•Vogel I et.al. Young People’s Exposure to Loud Music. A Summary of the Literature. *Am J Prev Med,* 2007, 33(2):124-133.

CONTENTS

Children and noise

PREVENTION AND INTERVENTION

- More research needed, especially in vulnerable groups
- Preventive action
  - Noise has to be controlled at the source
  - Hearing protection devices are a last resort
- Child hearing conservation programs
- Education and dissemination

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Future research:
•Effects of noise on cognitive functions.
•Effects of noise on children's sleep.
•Magnitude/significance of noise annoyance.
•Children's perception and risk perception.
•Settings: home, schools, hospital, day care centres.
•Teenagers' attention when driving and listening to loud music.
•Effect of non-audible noise.
•Identification of more vulnerable groups!
•Intervention programs/best practices for preventing harmful effects.

Preventive actions
Noise has to be controlled at the source by:
•Reducing.
•Enclosing the vibrating surfaces.
•Placing sound absorbers and other protections.
Hearing protection devices are a last resort!

Child hearing conservation program
•Noise monitoring where children live, study and play.
•Hearing protection programs diffusion for teachers and parents.
•Vibration detection and protection.
•Protection of the pregnant woman.

Education and dissemination

References:

•Folmer RL, et al. Hearing conservation education programs for children: a review. *J Sch Health.* 2002;72:51-7.

Prevalence of noise-induced hearing loss (NIHL) among children is increasing. Experts have recommended implementation of hearing conservation education programs in schools. Despite these recommendations made over the past three decades, basic hearing conservation information that could prevent countless cases of NIHL remains absent from most school curricula. This paper reviews existing hearing conservation education programs and materials designed for children or that could be adapted for classroom use. This information will be useful as a resource for educators and school administrators and should encourage further development, implementation, and dissemination of hearing conservation curricula. The overall, and admittedly ambitious, goal of this review is to facilitate implementation of hearing conservation curricula into all US schools on a continuing basis. Ultimately, implementation of such programs should reduce the prevalence of noise-induced hearing loss among children and adults.

•Moeller. Environmental Health, *Harvard University Press,* 1992.

WHERE TO INTERVENE?

- **Techniques for reducing or eliminating noise**
  - At the source
  - By installing a barrier between the source and the recipient
  - At the point of reception / At the human recipient
- **Potential settings for intervention**
  - NICU
  - Child care settings
  - Primary schools
  - Discotheques and rock festivals
- **Address external and internal noise sources**

<<READ SLIDE>>

Identified potential settings for intervention

1.NICU

2.Child care settings : more and more children stay in various child care settings. These play an important role in the initial stages of children beginning to establish their basic education.

3.Primary schools : primary school children often spend long periods of time in one classroom, and a noisy room can adversely affect the occupants of that room.

4.Discotheques and rock festivals : the noise level can be very high in discotheques, often resulting in tinnitus or a temporary threshold shift among patrons. Many major cities have festivals, and many of the noisier attractions inevitably appeal to younger people.

References:

•Bistrup M.L., Keiding L., ed. (2002). Children and noise - prevention of adverse effects. *Copenhagen, National Institute of Public Health* (also available at www.niph.dk).

•Byers JF, et al. Sound level exposure of high-risk infants in different environmental conditions. *Neonatal Netw.* 2006, 25(1):25-32.

PURPOSES: To provide descriptive information about the sound levels to which high-risk infants are exposed in various actual environmental conditions in the NICU, including the impact of physical renovation on sound levels, and to assess the contributions of various types of equipment, alarms, and activities to sound levels in simulated conditions in the NICU. DESIGN: Descriptive and comparative design. SAMPLE: Convenience sample of 134 infants at a southeastern quarternary children's hospital. MAIN OUTCOME VARIABLE: A-weighted decibel (dBA) sound levels under various actual and simulated environmental conditions. RESULTS: The renovated NICU was, on average, 4-6 dBA quieter across all environmental conditions than a comparable nonrenovated room, representing a significant sound level reduction. Sound levels remained above consensus recommendations despite physical redesign and staff training. Respiratory therapy equipment, alarms, staff talking, and infant fussiness contributed to higher sound levels. CONCLUSION: Evidence-based sound-reducing strategies are proposed. Findings were used to plan environment management as part of a developmental, family-centered care, performance improvement program and in new NICU planning.

Children and noise

HOW TO INTERVENE?

Technically

- Planning and designing outdoors and indoors “soundscapes”
- Improving road surfaces and developing green spaces and green barriers
- Developing noise barriers, building sound insulation
- Planning internal spaces according to activities (e.g. schools, sports-centres, others that involve noise), strategically using the space & location
- Reducing internal noise (eg. fans, ventilators)
- Using sound-absorbent materials
- Setting sound limits for concerts
- Increasing public and professional education to recognize noise pollution and reduction!

<<READ SLIDE>>

Children and noise

HOW TO INTERVENE?

Organizationally and Educationally

- Educating children, adults, professionals
- Teaching methods/interventions
- Disseminating information
- Informing the media and decision-makers and health professionals!
- Creating silent areas (“silence islands”) for resting
- Distributing earplugs at work and setting limits for the earphones
- Identifying and turning off noise at the source!

<<READ SLIDE>>

HOW TO INTERVENE?

Planning

- **Identifying noise sources and recognizing noise as a problem**
- **Recognizing health effects in children caused by noise**
- **Recognizing and diagnosing adults' health problems originated in childhood exposure**
- Raising awareness
- Setting-up noise control campaigns in hospitals and schools
- Applying the “Precautionary Principle”
- Thinking about noise exposure when planning the settings where children dwell
- Promoting sound landscape design
- Developing noise mapping, action plans, community involvement
- Standardizing noise measurements

<<READ SLIDE>>

Children and noise

POINTS FOR DISCUSSION

<<NOTE TO USER: Add points for discussion according to the needs of your audience.>>

Children and noise

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