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Via E-Mail and FedEx

Mayor Sam Liccardo and
Members of the City Council
200 E. Santa Clara Street
San José, California 95113
E-Mail: CityClerk@sanjoseca.gov

Re: Almaden Office Project, First Amendment to the Draft SEIR
FILE NO. SP20-005 (PREVIOUSLY H19-004)

Dear Mayor Liccardo and Members of the City Council:

This firm represents the Sierra Club Loma Prieta Chapter in connection with the proposed Almaden Office Project ("Project"). The proposed Project and the City's Supplemental Environmental Impact Report ("SEIR") suffer from numerous flaws. Most prominently, the Project conflicts with riparian protections embodied in the City's General Plan and City Council Policy 6-34: Riparian Corridor Protection and Bird Safe Design. In addition, the SEIR fails to comply with the requirements of the California Environmental Quality Act ("CEQA"), Public Resources Code § 21000 et seq., and the CEQA Guidelines, California Code of Regulations, title 14, § 15000 et seq.

This letter is submitted along with the reports prepared by Ric Reinhardt, consulting geohydrologist/civil engineer with MBK Engineers, attached as Exhibit 1 and Dr. Shani Kleinhaus, ecologist, attached as Exhibit 2. We respectfully refer the City to the aforementioned attached reports, both here and throughout these comments.

I. Background

The Project site is located immediately adjacent to the Guadalupe River, the Guadalupe River Trail, and surrounding riparian area. Initial Study at Figure 2.4-3. The Project is subject to Council Policy 6-34, which implements the 2040 General Plan goals, policies, and actions for the protection of riparian corridors and bird-safe design. As discussed in Section II below, Council Policy 6-34 requires new buildings in existing urban infill areas, such as the Almaden Project, to have a minimum 100-foot setback from riparian habitats. In contravention of City policy, the proposed Project includes an inadequate setback from the adjacent riparian area.

Approval of a project without the required riparian setback would set a harmful precedent for development adjacent to the City's riparian areas. Several proposed projects in the downtown area along the river and tributaries have already requested exceptions to City Policy 6-34. For example, the Downtown West Mixed-Use Plan (a.k.a. Google project) was granted a reduced setback from the riparian area. Similarly, the 280 Woz Way project is proposing a 35-foot setback from the Guadalupe River (rather than the required 100 feet). If each of these projects is granted a reduced setback, the City will effectively set a pattern of allowing setbacks that are between zero and 35 feet from the riparian area, in stark contrast to the 100-foot requirement.

For the proposed Project, the City is contemplating entirely waiving river setback requirements in contravention of City policy, resulting in the loss of even more riparian area along the river. The Project would crowd the River Trail and riparian area with an imposing 16-story glass building that would cast substantial shade on the adjacent public park and riparian areas. It would also significantly degrade existing riparian habitat, both through physical encroachment and by shading the area, which is anticipated to harm the long-term health and growth of plants. SEIR at 49. The Project's location immediately abutting this riparian area, without the required setback, could also degrade water quality in the Guadalupe River, and alter natural stream morphology and functions.

At a time when the City is promoting increased density downtown, the City should be enforcing its policies to protect and restore remaining riparian habitat and open spaces as natural respites for urban wildlife and as an amenity for City residents. Instead, the Project would allow construction of a massive building that is clearly out of scale for the site, and will have serious long-term consequences, not only for area residents, but for workers and visitors from the region. Those consequences include loss of open space; loss of riparian habitat; a significant loss of sunlight; visual impacts; an increased risk of erosion and sedimentation (both at the site and elsewhere on the river); and an increased risk of water pollution. Perhaps most egregious, setting a precedent for reduced or non-existent riparian setbacks for other projects proposed along the river would lead to further degradation of the river and riparian areas.

The SEIR suffers from several major problems and is insufficient to support approval of the Project. First, the SEIR describes the Project in a manner that is both incomplete and misleading to the public and decision-makers. As discussed in more detail below, the SEIR ignores or substantially understates the severity and extent of a range of environmental impacts, including, but not limited to, effects on hydrology, water quality, and biological resources. In addition, in numerous places, the SEIR fails to adequately analyze the Project's cumulative impacts.

To ensure that the public and the City's decision-makers have adequate information to consider the effects of the proposed Project—as well as to comply with the law—the City must require Project revisions to comply with the General Plan and City Policy 6-34, and then circulate a revised SEIR that properly describes the whole of the Project, analyzes all of its impacts (direct, indirect, and cumulative), and considers meaningful, feasible mitigation measures that would ameliorate those impacts. *See* CEQA Guidelines § 15002(a)(1) (one of CEQA's "basic purposes" is to "[i]nform governmental decision makers and the public about the potential, significant environmental effects of proposed activities"). Alternatively, the City should consider approval of a Reduced Development Alternative Project that would include a larger setback consistent with General Plan and City Policy requirements to protect riparian habitat and water quality.

II. Approval of the Proposed Project Violates the City's Riparian Setback Requirements.

A. The City's Riparian Corridor Policy Study requires a minimum 30-foot setback, which the Project violates.

The 1999 Riparian Corridor Policy Study establishes that "development adjacent to riparian habitats generally should be set back 100 feet from the outside edge of the riparian habitat (or top of bank, whichever is greater)." Policy Study at 31. While the Policy Study provides limited exceptions to this setback requirement, including exceptions for locations in or near Downtown San Jose and urban infill locations, the Policy Study is clear that these minimum reduced setbacks "should be . . . no less than 30 feet or no less than the average of existing setbacks on adjacent properties, whichever is greater." Policy Study at 33. Simply put, "[m]inimum reduced setbacks for those limited redevelopment sites described under the Setback Exceptions section . . . *should never* be less than 30 feet." *Id.* (emphasis added).

The Project does not conform with the Policy Study's setback requirement. Even if the Project qualifies for an enumerated exception that would allow a reduction of the standard 100-foot setback, the Policy Study is clear that the Project's setback can *never* be less than 30 feet. Here, however, the Project setback would be between zero and approximately 26 feet from the riparian corridor along the length of the site and would encroach within approximately 1.8-acres of the 100-foot setback area. SEIR at 49. The Project towers' upper floors would have a setback ranging from 3.92 feet to 32.5 feet to the edge of the riparian corridor and the underground parking garage would have a setback ranging from 1.5 feet to 34.25 feet to the edge of the riparian corridor. PC Staff Report, Item 5.a at 10. Any Project setback less than 30 feet violates the mandates from the Policy Study.

In addition, the Policy Study only allows for reduced setback requirements under certain conditions. It specifies that in certain circumstances "a reduced setback may be considered if:

> "There is no evidence of stream bank erosion or previous attempts to stabilize the stream banks which could be *negatively affected by the proposed development*."

Policy Study at 32. In this case, as discussed in more detail in the MBK Engineers Report, the proposed Project site has visible erosion on the stream bank. *See* MBK Report at 5 and accompanying attachment A. In addition, as the MBK Report explains, the Project as proposed (with only zero to 26 feet from the riparian area) will reduce the area of flood plain, which would limit local agencies' ability to mitigate flood risk, and which would likely result in the need to remove significant portions of the riparian area to accommodate a floodwall or other forms of bank protection. These measures will not only negatively affect the stream bank, but will also further the degrade the riparian area.

B. The Planning Commission Staff Report erroneously argues Council Policy 6-34 replaces the Policy Study.

The City attempts to circumvent the Policy Study's mandatory requirements by claiming that "[t]he 2016 adopted Council Policy 6-34 replaces the 1999 Riparian Corridor Policy Study." *See* PC Staff Report, Item 5.a at 7. This argument is false.

As a threshold matter, the City's existing General Plan *requires* compliance with the Policy Study. Specifically, under General Plan Policy ER-2.1, the City must "ensure that new public and private development adjacent to riparian corridors in San Jose are consistent with the provisions of the City's Riparian Corridor Policy Study." The City has not replaced this General Plan policy, and cannot write its way around the General Plan's express requirement to comply with the Policy Study. Approving the Project in violation of the Policy Study's setback requirements violates the General Plan itself.

Nor does Council Policy 6-34 suggest that it is meant to override the standards in the Policy Study. In fact, Council Policy 6-34 states the opposite: its "general guidelines for setbacks from Riparian Corridors" are "consistent with recommendations from the Policy Study." Council Policy 6-34 at 3.

The City Council adopted Council Policy 6-34 on August 23, 2016 to provide guidance consistent with the 2040 General Plan goals, policies and actions for the protection of riparian corridors and bird-safe design, which themselves require compliance with Policy Study. *See* Staff Report for the August 25, 2021 Planning Commission hearing (hereafter "PC Staff Report"). Council Policy 6-34 was developed based on the Policy Study and the Habitat Conservation Plan in order to further implement the General Plan's riparian goals and policies. First Amendment to SEIR at 7-9. Council Policy 6-34 provides guidance on how projects should be designed to protect and preserve the City's riparian corridors, such as incorporating "riparian setback recommendations and exceptions from the 1999 Policy Study." PC Staff Report, Item 5.a at 7.

Like the Policy Study, Council Policy 6-34 requires a minimum 100-foot setback from riparian habitats for new buildings in existing urban infill areas, new residential buildings, as well as commercial/institutional buildings. Neither the PC Staff Report nor the SEIR dispute that the Project is subject to this minimum setback requirement. PC Staff Report, Item 5.a at 10; First Amendment to SEIR at 8. Instead, the City argues that the Project falls under the enumerated exceptions to the 100-foot setback requirement and is thus entitled to a reduced setback. *Id.* However, even if true, a reduced setback does not mean no setback or an arbitrarily determined setback, as the City appears to advocate. *See* PC Staff Report, Item 5.a at 7, 15; First Amendment to SEIR at 8-9.

Rather than provide a specific limitation on reduced setbacks, Council Policy 6-34 *relies on* the Policy Study to supplement its own guidance. According to Council Policy 6-34, the setback and buffer widths provided in Council Policy 6-34 "are intended to provide *general guidance* for site design. For actual setback and buffer dimensions, the specific setbacks section in Chapter 3 of the Policy Study *should* be consulted." Council Policy 6-34 at 3, fn. 2 (emphasis added). Thus, Council Policy 6-34 does not supersede the Policy Study, but rather incorporates its specific setback requirements. *Id.*

The Policy Study and Council Policy 6-34 work together to establish requirements for development adjacent to the City's riparian habitats. The documents themselves are clear: the purpose of Council Policy 6-34 is to provide "*general guidelines*" (Council Policy 6-34 at 3) while the Policy Study "explore[s] *in detail*" setback policies for riparian corridors. Policy Study at 1. Read together, the mandate is unambiguous: 100-foot setbacks may be reduced if a project falls under an enumerated exception, but under no circumstances may the reduced setback be less than 30 feet. The Project plainly conflicts with this binding requirement.

C. The City has recently confirmed that the Policy Study is still binding.

Moreover, contrary to staff's assertion, the City has continued to rely on the Policy Study following adoption of Council Policy 6-34. The City's website and recent planning documents repeatedly cite to the Policy Study for riparian development standards, confirming that the Policy Study is still binding and has not been superseded. As of September 7, 2021, the City of San Jose website clearly states that the Policy Study "supplements the riparian . . . policies of the General Plan," and "describes how development adjacent to these corridors should be limited or controlled to avoid environmental damage."[1]

The 2019 Master Plan Amendment for the Mineta San Jose International Airport similarly incorporates and utilizes the Policy Study. According to the Master Plan Amendment's Biological Resources Report, the City's "riparian buffer policy is administered through use of a Riparian Corridor Policy Study document that describes suggested buffer widths."[2]**Error! Hyperlink reference not valid.** Additionally, the 2020 Biological Report for the Villa Del Sol Mixed-Use Project explains that that Policy Study, which was "*codified as policy*" through Council Policy 6-34, dictates circumstances that may warrant consideration of setbacks less than 100 feet.[3] The Villa Del Sol report goes on to confirm that the Policy Study, together with Council Policy 6-34, the Habitat Plan, and the City's General Plan "currently *define* the City of San Jose's riparian corridor policy."[4] The City cannot arbitrarily argue that the Policy Study is irrelevant or superseded by Council Policy 6-34 for the propose Project when the City continues to recognize the Policy Study's requirements for other projects.

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[1]Policy Studies, City of San Jose Website, available at https://www.sanjoseca.gov/your-government/departments/planning-building-code-enforcement/planning-division/about-us/policy-studies.
[2]Master Plan Amendment for Mineta San Jose International Airport Biological Resources Report at 77, available at https://www.sanjoseca.gov/home/showpublisheddocument/61652/637304476601070000.
[3]Villa Del Sol Project Riparian Habitat Evaluation at 9, available at https://www.sanjoseca.gov/home/showpublisheddocument/68681/637469341716670000 (emphasis added).
[4]Villa Del Sol Project Riparian Habitat Evaluation at 5, available at https://www.sanjoseca.gov/home/showpublisheddocument/68681/637469341716670000 (emphasis added).

III. Approval of the Project Is Inconsistent with the City's General Plan.

The state Planning and Zoning Law (Gov't Code § 65000 et seq.) requires that development approvals be consistent with a jurisdiction's general plan. "Under state law, the propriety of virtually any local decision affecting land use and development depends upon consistency with the applicable general plan and its elements." *Resource Defense Fund v. County of Santa Cruz* (1982) 133 Cal.App.3d 800, 806. Accordingly, "[t]he consistency doctrine [is] the linchpin of California's land use and development laws; it is the principle which infuses the concept of planned growth with the force of law." *Families Unafraid to Uphold Rural El Dorado County v. Board of Supervisors* (1998) 62 Cal.App.4th 1332, 1336.

It is an abuse of discretion to approve a project that "frustrate[s] the General Plan's goals and policies." *Napa Citizens for Honest Gov't v. Napa County* (2001) 91 Cal.App.4th 342, 379. A project need not present an "outright conflict" with a general plan provision to be considered inconsistent; the determining question is instead whether the project "is compatible with and will not frustrate the General Plan's goals and policies." *Napa Citizens*, 91 Cal.App.4th at 379.

Here, the proposed Project does more than just frustrate the General Plan's goals. It plainly conflicts with the City of San Jose's General Plan, specifically General Plan policies that protect riparian resources such as ER-2.1 and ER-2.2. General Plan Policy ER-2.1 requires development to be "consistent with the provisions of the City's Riparian Corridor Policy Study and any adopted Santa Clara Valley Habitat Conservation Plan/Natural Communities Conservation Plan (HCP/NCCP)." As described above, the Project's proposed setbacks would violate the Policy Study by allowing development within 30 feet from riparian habitats, and would therefore be inconsistent with General Plan Policy ER-2.1. *See* Section II.A., supra.

Additionally, General Plan Policy ER-2.2 specifically requires a 100-foot setback from riparian habitat "in all but a limited number of instances, *only where no significant environmental impacts would occur*." (Emphasis added.) The SEIR concludes that encroachment of the project within the 100-foot setback would result in significant unavoidable impacts to adjacent riparian communities, including reduction of wildlife, habitat shading, and expected bird collisions. SEIR at 47 ("The proposed project would result in a significant unavoidable cumulative impact to the Guadalupe River riparian corridor beyond what was evaluated in the Downtown Strategy 2040."); 49 (detailing expected impacts to riparian corridor). But the Project is not setback 100-feet from riparian habitats. This plainly violates General Plan Policy ER-2.2.

IV. The City Cannot Make the Findings Needed to Approve the Project.

As detailed in the PC Staff Report, the City must make a number of findings to lawfully approve the Project. Substantial evidence in the record fails to support a number of these findings.

For example, in order to issue a Special Use Permit for the Project, the City must find that the special use permit is "consistent with and will further the policies of the general plan." San Jose Municipal Code § 20100.820 (A)(1). The Special Use permit must also be "consistent with applicable city council policies." *Id.* § 20100.820 (A)(3); *See also* Section 20.110.630 (establishing same standard). Moreover, section 20.100.820 requires that any such Findings have to be substantiated or the decision-making body shall deny the application. *Id*. at B.

The record lacks substantial evidence to support these findings. As described above, the Project's proposed setbacks would violate the Policy Study and General Plan policies ER-2.1 and 2.2 by allowing development within 30 feet from riparian habitats and ignoring the General Plan's prohibition of setbacks less than 100 feet when significant environmental harm will result. *See* Section III., supra. In addition, the SEIR itself demonstrates that the Project would have several impacts that would render it incompatible with not just these policies, but also Council Policy 6-34. *See* Section II., supra. The development would also generate substantial environmental impacts, including significant, unmitigated project and cumulative impacts to the adjacent riparian habitat and bird species from noise, pollution, increased traffic, and construction. *See* Section VI., VII., infra.

Despite these inconsistencies, the City's CEQA Findings erroneously conclude that the Project is consistent with each of the Zoning Code's requirements. *See* PC Staff Report, Item 5.a at 20-23. These Findings however cannot be supported by substantial evidence and do not supply the logical step between the proposed decision and the facts in the record, as required by state law. Indeed, the City's Findings are directly contradicted by evidence in the Project's planning documents, as described throughout this letter. As a result, the City cannot lawfully rely on these Findings to support approving the Project.

V. The SEIR's Flawed Project Description Impairs Meaningful Public Review of the Project.

Under CEQA, the EIR's inclusion of a clear and comprehensive description of the proposed project is critical to meaningful public review. *County of Inyo v. City of Los Angeles* (1977) 71 Cal.App.3d 185, 193. *County of Inyo* explained:

> "A curtailed or distorted project description may stultify the objectives of the reporting process. Only through an accurate view of the project may affected outsiders and public decision-makers balance the proposal's benefit against its environmental cost, consider mitigation measures, assess the advantage of terminating the proposal (i.e., the "no project" alternative) and weigh other alternatives in the balance."

Id. at 192-93. Thus, "[a]n accurate, stable and finite project description is the *sine qua non* of an informative and legally sufficient EIR." *San Joaquin Raptor/Wildlife Rescue Center v. County of Stanislaus* (1994) 27 Cal.App.4th 713, 730. Courts have found that even if an EIR is adequate in all other respects, the use of a "truncated project concept" violates CEQA and mandates the conclusion that the lead agency did not proceed in the manner required by law. *Id.* at 729-30.

The description of the proposed Project is unstable because it has continually shifted since the start of the CEQA process. A table of Minimum Setback from Boundaries, provided in the First Amendment to the Draft SEIR shows that, since January 2019, the proposed Project setbacks from various boundaries have changed at least three times. First Amendment to the Draft SEIR, Master Response 1 at page 6. In addition, the project description has been altered yet again since publication of the First Amendment to the Draft SEIR in August 2021. The PC Staff Report indicates that on "April 15, 2021, BXP Almaden Associates LP filed a Vesting Tentative Map application, File No. T21-015, to merge all existing lots to one lot for up to 15-commercial condominium units." PC Staff Report, Item 5.a at 2. This change includes not only a change in uses on the site, but an increase of 322,223 square feet (*i.e.*, the Project increased from 1,727,777 square feet to 2,050,000 square feet), a nearly 20 percent increase in the size of the Project. SEIR at iii and First Amendment to the Draft SEIR at 6 and PC Staff Report, Item 5.a at 3, respectively. The PC Staff Report fails to include a graphic showing where on the site the proposed condominiums would be located. It fails to explain whether the building footprint would increase and how the Project would incorporate an additional 322,223 square feet without increasing the square footage or building height. In sum, neither the PC Staff Report nor the Council Staff Report include any additional information or analysis of potential impacts resulting from this last-minute project change.

In addition, the SEIR fails to describe aspects of the Project that are essential for the SEIR to provide a meaningful environmental analysis. In some cases, important aspects of the Project are omitted altogether. For example, the SEIR fails to include both the Construction Operations Plan and the Construction Noise Logistics Plan intended to describe hours of construction, noise and vibration minimization measures, and equipment to be used, among other elements. SEIR at iv and xi, respectively. The SEIR must disclose information from these plans as these Project features will result in traffic, noise, and air quality impacts on area residents. Without this information, it is impossible to understand the full scope of these impacts.

The Initial Study also indicates that the Project site contains contaminated soil and groundwater. Initial Study at 66. A Site Cleanup Program is therefore required by the Santa Clara County Department of Environmental Health to evaluate the past uses of the property, and the agency may require a Phase II Environmental Site Assessment, a Groundwater Management Plan, and other studies to ensure the Project is safe for construction workers and future site occupants. SEIR at x and First Amendment to the Draft SEIR, Comment and Response L.10 at 79 and 80. The SEIR should have included the Site Cleanup Program and a Groundwater Management Plan so that related impacts could be evaluated now, rather than deferred to future regulatory processes. *See Banning Ranch Conservancy v. City of Newport Beach* (2017) 2 Cal.5th 918, 936 (CEQA requires agencies to "integrate" their environmental review with other environmental regulations "to the maximum feasible extent" so that environmental permitting processes run concurrently, not consecutively). Here, providing this information is necessary to allow the public and decision-makers to review and evaluate the elements of these proposed plans to understand whether they adequately address concerns related to contaminated soils and groundwater. (To the extent the City would treat these plans as mitigation rather than part of the Project, their omission from the SEIR would be an impermissible deferral of mitigation.)

CEQA does not allow an EIR to fold what is effectively an assumed mitigation measure into a significance determination—the project's significant impacts must be determined first, and then the EIR must identify enforceable mitigation that will "offset" the impacts. *See Lotus v. Department of Transportation* (2014) 223 Cal.App.4th 645, 656, 658 (rejecting EIR that relied on project modifications to find no significant impact, instead of identifying significant impacts and considering mitigation measures). *Lotus* held that an EIR was legally inadequate where it assumed certain mitigation techniques would be incorporated into the project, and thus the EIR did not disclose the impacts of the project without those special techniques. *See id*. Further, the court in Lotus held that the EIR there was inadequate because it "fail[ed] to discuss the significance of the environmental impacts apart from the proposed 'avoidance, minimization, and/or mitigation measures' and thus fail[ed] to consider whether other possible mitigation measures would be more effective." *Id*. at 657. Such is the case here: the SEIR relies on a variety of deferred plans as a key factor in its determination that a list of Project-related impacts would be less than significant. *See, e.g.,* SEIR at x. In so doing, the SEIR fails to reveal the true nature of the impacts and consider other feasible mitigation measures and their effectiveness, in violation of CEQA.

Even where the SEIR describes Project features, the description is incomplete. For instance, the SEIR fails to provide any information regarding the construction of the proposed commercial condominiums, which were only added after the SEIR was finalized. The SEIR also fails to include any information on design provisions to address energy conservation. The SEIR merely asserts that the Project will comply with Council Policy 6-32 and the City's Green Building Ordinance, but fails to explain how the Project will do so. SEIR at 11, 23, and 82.

The SEIR also fails to include information on the following Project components:

- information on planned construction activities and construction schedule (SEIR at 11);
- location of the Project construction staging areas and machinery storage (SEIR at 11);
- amount of proposed soil removal, where it will be stored, and how it will be disposed of; and
- dewatering volumes and durations.

This information is critical to disclose, especially for a construction project lasting five years or longer that will result in visual, noise, and air quality impacts to area residents and will also impact water quality and biological resources. Yet, the SEIR omits details of the locations of these activities and project elements. In addition, the SEIR omits disclosure and description of the Project approvals necessary from agencies other than the City (*e.g.*, Santa Clara County Department of Environmental Health, and Santa Clara Valley Water District).

In sum, the SEIR presents an incomplete and unstable project description, which also lacks additional Project details that may be contained in a Development Agreement. This approach is not permissible under CEQA. The failure to describe the whole of the Project is a serious and pervasive deficiency, as it renders faulty the SEIR's environmental impact analyses as well as the discussion of potential mitigation measures and alternatives to minimize those impacts. The SEIR must provide a sufficient description of off-site improvements associated with the Project, information regarding required plans to minimize Project-related construction and operational impacts, details of anticipated construction activities, and any other Project details. This information is necessary to allow decision makers, the public and responsible agencies to evaluate potential environmental impacts.

VI. The SEIR's Analysis of and Mitigation for the Impacts of the Proposed Project Are Inadequate.

An EIR is "the heart of CEQA," and should be of the highest quality, giving both decision-makers and the public a full opportunity to understand and analyze environmental repercussions of the Project. *Laurel Heights Improvement Ass'n v. Regents of University of California* (1988) 47 Cal.3d 376 at 392. "The EIR is also intended 'to demonstrate to an apprehensive citizenry that the agency has, in fact, analyzed and considered the ecological implications of its action.' Because the EIR must be certified or rejected by public officials, it is a document of accountability." *Id*. at 392 (citations omitted). The SEIR fails to live up to this mandate.

An EIR must provide enough analysis and detail about environmental impacts to enable decision-makers to make intelligent judgments in light of the environmental consequences of their decisions. The City, as lead agency, must make a good faith effort to disclose the Project's direct and cumulative impacts. Unfortunately, the SEIR fails to meet even the most basic objectives of CEQA and deprives the public and decision-makers of any opportunity to understand the environmental repercussions of the Project. Where, as here, the environmental review document fails to fully and accurately inform decision-makers and the public of a project's environmental consequences, it violates CEQA. *See* Pub. Resources Code § 21061.

As explained below, the SEIR fails to analyze the Project's numerous environmental impacts, including those affecting hydrology, water quality, and biological resources. These inadequacies require that the EIR be revised and recirculated so that the public and decision-makers are provided with a proper analysis of the Project's environmental impacts and feasible mitigation for those impacts. *See* CEQA Guidelines §15002(a)(1) (one of CEQA's "basic purposes" is to "[i]nform governmental decision makers and the public about the potential, significant environmental effects of proposed activities").

A. Land Use

As explained in section II above, the proposed Project fails to comply with the City's policies and ordinance for riparian setbacks. Under CEQA, an inconsistency or conflict between a plan or ordinance and the Project is a significant impact that must be disclosed and analyzed. The SEIR misses the mark in its evaluation of these issues.

The SEIR acknowledges that numerous policies of the Envision San Jose 2040 General Plan apply to the Project. SEIR at 41-43. However, as discussed above in section III, the SEIR fails to adequately consider the Project's inconsistency with the General

Plan. These plain inconsistencies represent significant impacts that the SEIR fails to acknowledge.

The PC Staff Report attempts to rectify the SEIR's lack of General Plan consistency analysis, but ultimately falls short. The PC Staff Report's General Plan consistency analysis regarding riparian corridor policies focuses exclusively on conformance with ER-2.1. PC Staff Report, Item 5.a at 6-7. In its analysis of the policy, the PC Staff Report wrongly concludes that the Project is consistent with General Plan Policy ER-2.1. *Id.* However, as discussed above, General Plan Policy ER-2.1 requires compliance with the Riparian Corridor Policy Study, which the PC Staff Report cannot and does not show. *See* Section II., supra. Moreover, the PC Staff Report does not claim that the Project is consistent with any of the other riparian corridor policies in the General Plan, including General Plan Policy ER-2.2. *See* PC Staff Report, Item 5.a. at 7. Nor can it, as the Project plainly conflicts with ER-2.2. *See* Section III., supra.

Additionally, as discussed in section II above, the SEIR asserts that the Project is consistent with City Council Policy 6-34, based on the assumption that the Project qualifies for an exception from mandatory riparian setbacks. However, the SEIR fails to acknowledge that the Project does not comply with the City's riparian setback requirements, whether 100 feet or 30 feet.

The SEIR's failure to properly acknowledge and analyze these land use impacts renders the document legally adequate, and the record lacks substantial evidence to support any conclusion that these impacts will be less than significant.

B. Riparian Habitats

The Project does not comply with the Downtown Strategy 2040 FEIR's proposed mitigation for riparian habitats. Nor does the Project comply with mitigation measures adopted in the City's General Plan EIR to protect riparian habitats.

The Downtown Strategy 2040 FEIR assumes compliance with the General Plan policies for riparian corridors, including policies ER-2.1 and ER-2.2. The Downtown Strategy 2040 FEIR even admits that the "intensification of urban development in the vicinity of the Guadalupe River and Los Gatos Creek would result in a substantial adverse effect" to the environment. Downtown Strategy 2040 FEIR at 80. However, unlike this SEIR, the Downtown Strategy 2040 FEIR requires compliance with General Plan Policy ER-2.2 and Council Policy 6-34 to mitigate any impacts to riparian habitats: "For specific projects adjacent to the riparian corridor a setback will be established in accordance with . . . development guidelines in City Council Policy 6-34 . . . and General Plan Policy ER-2.2."[5]

Similarly, compliance with the Policy Study is included in Envision San Jose 2040 General Plan as part of policies and actions that provide "program-level mitigation for impacts to fish and wildlife movement" as well as "sensitive communities and habitats within the City."[6]

Here however, the Project does not conform with General Plan policies ER-2.1-2.2, nor does the Project comply with the Policy Study, as discussed above. *See* Sections II., III, supra. Accordingly, the Project violates the mitigation underlying both the Downtown Strategy 2040 FEIR and the City's General Plan EIR.

CEQA forbids deleting or modifying previously-adopted mitigation measures like compliance with the General Plan policies and the Council Policy 6-34 "without a showing that it is infeasible." *Napa Citizens for Honest Government*, 91 Cal.App.4th at 359; *see also Sierra Club v. County of San Diego* (2014) 231 Cal.App.4th 1152, 1167 ("mitigation measures cannot be defeated by ignoring them"); *Katzeff v. California Dept. of Forestry and Fire Protection* (2010) 181 Cal.App.4th 601, 611 (mitigation measures are not "nullified by the passage of time"). Additionally, if an agency pursues modification of mitigation, it must conduct additional environmental review to evaluate the environmental impacts of changing its mitigation. *Lincoln Place Tenants Assn. v. City of Los Angeles* (2005) 130 Cal.App.4th 1491, 1509; 1 Kostka & Zischke, Practice Under the Cal. Environmental Quality Act (2d ed. 2015) § 14.35, pp. 14-44 to 14-45 ("reasons for deleting the mitigation measure . . . must be addressed in a supplemental EIR or other CEQA document such as an addendum").

Here, the Project fails to comply with mandatory mitigation requirements in both the Downtown Strategy 2040 FEIR and the City's General Plan EIR in violation of CEQA. Because the Project fails to comply with the Downtown Strategy 2040 FEIR, the City cannot rely on that document to justify its conclusion that development of the Project will not result in significant impacts to riparian corridors.[7]

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[5]Downtown Strategy 2040 Integrated Final EIR at 80, available at https://www.sanjoseca.gov/home/showpublisheddocument/44054/637082061948370000.
[6]Envision San Jose 2040 General Plan, Draft Program EIR at 464, 476, available at https://www.sanjoseca.gov/home/showpublisheddocument/22039/636688304347700000
[7]The Project's inconsistencies with the Downtown Strategy 2040 program and the General Plan also the prevent the City from tiering the Project's CEQA analysis from the

C. Hydrology and Water Quality Impacts

The Initial Study fails to address Project-related impacts related to hydrology and water quality as a result of a series of errors, including: (1) the failure to consider applicable guidance regarding development in floodplains, which would increase the likelihood of bank hardening in the future; (2) the failure to disclose the extent and severity of impacts related to erosion and sedimentation; and (3) the failure to identify feasible mitigation measures. The SEIR's treatment of hydrology impacts does not meet CEQA's well established legal standard for impacts analysis. Given that analysis and mitigation of such impacts are at the heart of CEQA, the SEIR will not comply with the Act until these serious deficiencies are remedied.

The report prepared by MBK Engineers, which is incorporated by reference, provides detailed comments on the SEIR's inadequate hydrology analysis. *See* MBK Engineers Report attached as Exhibit 1. The discussion below highlights the most egregious deficiencies.

1. The SEIR Fails to Disclose the Extent and Severity of Foreseeable Impacts Related to Erosion and Sedimentation.

The existing riverbank is in its natural state and has no added bank protection. *See* MBK Report, Attachment A (photos of the riverbank at the Project site.). According to the MBK Report, over time, the natural riverine geomorphic processes are expected to increase erosion in the Project area. MBK Report at 5. As explained above, given that the proposed Project would not have an adequate setback from the riparian area, it is foreseeable that local agencies would have to seek a hardscape solution to protect the proposed building from flood risks. MBK Report at 3 and 5. Construction of a hardscape solution, such as riprap, would require removal of the riparian vegetation for construction. Installation of riprap, or similar bank protection methods will establish a hard point in this reach of the river and would lead to increased erosion upstream and downstream of the site. MBK at 5. Managing flood risk in this way would further exacerbate sedimentation in the Guadalupe River, harming water quality and aquatic

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Downtown Strategy 2040 FEIR. *See* CEQA Guidelines § 15152. The SEIR should have conducted an independent CEQA analysis.

habitat downstream.[8] The SEIR fails to evaluate these impacts, and consequently, fails to evaluate mitigation necessary to avoid them.

As the MBK Report explains, an adequate setback from the riparian area would allow for more flexibility in permitting the natural riverine processes to occur, and would provide more flexibility in addressing erosion in ways that preserve the existing riparian vegetation. MBK Report at 5.

2. The SEIR's Failure to Consider Guidance on Floodplain Development Ignores Foreseeable Floods at the Project Site, Which Increase the Likelihood of Bank Hardening.

The Initial Study concludes that the Project site is not subject to any restrictions on development because it is not located in the Federal Emergency Management Agency (FEMA) 100-year floodplain. MBK Report at 1. But even if the site does not face flood-related restrictions, it does not mean that a building so close to the Guadalupe River would be free from potential flood threats. As explained in the MBK Report, the site's designation as a Shaded Zone X site indicates that it is in an area at risk of flooding for events greater than a historical 100-year risk, but less the 500-year risk. MBK at 1.

The Initial Study's deficient analysis ignores State and Federal guidance related to development in the floodplain. The MBK Report explains the importance of considering such guidance, such as the Federal Flood Risk Management Standard (FFRMS), the California Water Resiliency Portfolio, and the California Flood Future Report regarding flood risk given that climate change is increasing the frequency and intensity of extreme flood events. *Id*. These standards and guidance documents provide more current information and recommendations that account for changing conditions due to climate change. The SEIR's failure to consult such guidance understates the flood risk at the Project site.

Significantly, approving a Project within 35 feet of the top of the riverbank would result in insufficient right-of-way (area between the riverbank and the proposed structure) to respond to flooding concerns in the future. For example, when the 100-year flow increases as forecasted with climate change, or the City or Valley Water decide to provide higher levels of protection, a floodwall would likely be needed. Construction of a

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[8] *See*, https://www.epa.gov/caddis-vol2/caddis-volume-2-sources-stressors-responses-urbanization-riparian-channel-alteration and Santa Clara Valley Water District Bank Protection/Erosion Repair Design Guide available at https://www.valleywater.org/sites/default/files/GS%20Ch%204%20Bank%20Protection%20Erosion_0.pdf and attached as Exhibit 3.

floodwall would require removal of a significant portion of the riparian corridor because the development is not setback far enough from the top of the streambank. MBK Report at 2 and 3. In fact, urban areas have long recognized the need for higher levels of flood protection than FEMA's minimum standard of limiting development to outside the 100-year flood risk designation. For instance, several cities including Lathrop, Stockton, Manteca, Sacramento, West Sacramento, Woodland and Marysville, have a 200-year flood risk minimum standard. *Id*. at 3. Sacramento and Yuba counties are currently seeking to pass the 500-year flood risk minimum standard in their urban areas. *Id*.

State guidance regarding right-of-way criteria for floodwalls in urban areas recommends expanding right-of-way areas for higher levels of flood protection, anticipated and unanticipated changes in design criteria, and updated hydrology/hydraulics and other data needed to maintain urban level flood protection. State of California's Urban Levee Design Criteria (ULDC), Section 7.11 and MBK Report at 3. This guidance recommends flood rights-of-way for future needs that are at least 50 feet. *Id*. and ULDC, Section 7.11.2. The recommendation is that the right-of-way would not contain structures, though open space, trails, outdoor recreation and other compatible uses could be allowed within the right-of-way.

By contrast, allowing development of a large office Project within 20 feet of the top of bank without an adequate setback will restrict how local agencies can respond to mitigating flood risk in the future and will increase the costs of providing flood protection. *Id*.; SEIR at 46. If flood risk in the Project area increases as predicted, flood protection measures would likely require the removal of significant portions of the riparian corridor adjacent to the Guadalupe River to construct a floodwall and install bank protection. These measures would, in turn, result in significant changes to the river that will exacerbate erosion and flooding downstream. MBK Report at 5. The SEIR fails to consider these flood risks and the indirect impacts that will result from them.

By ignoring necessary flood protections, the SEIR takes a piecemeal approach to environmental review and foregoes analysis of impacts resulting from implementation of flood protection elements. CEQA, however, prohibits such segmentation of a project. *See Tuolumne County Citizens for Responsible Growth, Inc. v. City of Sonora* (2007) 155 Cal.App.4th 1214, 1229 ("when one activity is an integral part of another activity, the combined activities are within the scope of the same CEQA project" and must be analyzed together); CEQA Guidelines § 15378(a) ("'Project' means the whole of an action, which has a potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment."). Breaking the project into smaller sub-projects or failing to consider the reasonably foreseeable consequences of a project will lead to inadequate environmental review. *See Bozung v. Local Agency Formation Comm'n* (1975) 13 Cal.3d 263, 283-84 (CEQA mandates that "environmental considerations do not become submerged by chopping a large project into many little ones"); *see also Laurel Heights Improvement Ass'n v. Regents of the University of California* (1988) 47 Cal.3d 376, 396 ("*Laurel Heights I*") ("[A]n EIR must include an analysis of . . . reasonably foreseeable consequence[s] of the initial project" that "change the scope or nature of the initial project or its environmental effects").

In sum, the SEIR fails to consider the site's increased exposure to flooding due to climate change, and the foreseeable environmental impacts from protecting the Project from flooding. Allowing development without an adequate setback from the riparian area would restrict local agency response to flood risk mitigation, thereby increasing the likelihood of the need for bank hardening. This flaw will, in turn, lead to increased erosion and sedimentation in the Guadalupe River. A revised SEIR that adequately describes the Project and comprehensively evaluates and mitigates the proposed Project's flood-related impacts must be prepared and recirculated.

3. The Project's Initial Study and SEIR Impermissibly Rely on Compliance with Existing Regulations to Mitigate Significant Impacts Related to Hydrology and Water Quality.

The Project's Initial Study and SEIR impermissibly relies on compliance with existing laws and regulations to mitigate Project-related hydrology impacts and to conclude that related impacts would be less than significant. For example, the Initial Study implies that state regulations requiring review and oversight of the erosion control system by the Regional Water Board will ensure that potential impacts will be avoided or mitigated. Initial Study at 49. Similarly, in response to California Department of Transportation comments stating that surface runoff from the Project site must be evaluated and mitigated to pre-construction levels (First Amendment to the SEIR, Comment B.4 at 14), the SEIR states that the Project would comply with City's Post-Construction Urban Runoff Policy 6-29 and the Mitigation Monitoring and Reporting Program to reduce stormwater runoff from the proposed project.

Aside from stating the Project proposes media filters and flow through planters to treat stormwater, the SEIR fails to describe how the Project would comply with the applicable regulations. In addition, dewatering discharge can also add pollutants and sediment, impacting water quality. The SEIR fails to quantify the amount of expected wastewater from the dewatering process, or how it would be treated, and fails to provide information on the rate and volume of expected wastewater discharge after treatment. SEIR Appendix F at 25-29 and MBK Report at 5.

Under well-established case law, an agency may not use compliance with regulations to avoid describing Project activities or from analyzing resulting impacts. *Oro Fino Gold Mining Corporation v. County of El Dorado* (1990) 225 Cal.App.3d 872, 885. The City fails to provide any explanation or evidence to support the conclusion that the Project's impacts on water quality are less than significant. *See* Initial Study at 49.

In sum, the SEIR must clearly and consistently describe each of the Project's elements and perform the necessary analysis prior to Project approval. Without this information, it is simply not possible to verify the accuracy of the SEIR's analysis of the Project's impacts related to on-site hydrology and water quality. As to downstream impacts from increased erosion and sedimentation, the SEIR has entirely skipped over the required analysis and is wholly inadequate. A legally adequate analysis must consider the aforementioned significant impacts and identify feasible, effective mitigation or alternatives to avoid or minimize the impacts.

D. The SEIR Fails to Disclose the Extent of the Project's Significant Biological Resources Impacts or to Adopt All Feasible Mitigation Measures.

1. The SEIR Mischaracterizes the Existing Setting of the Project Site and Adjacent Riparian Habitat.

Accurate and complete information pertaining to the setting of the Project and surrounding areas is critical to an evaluation of a Project's impact on the environment. *San Joaquin Raptor/Wildlife Center v. Stanislaus County* (1994) 27 Cal.App.4th 713, 728; *see also Friends of the Eel River v. Sonoma County Water Agency* (2003) 108 Cal.App.4th 859, 875 (incomplete description of the Project's environmental setting fails to set the stage for a discussion of significant effects). An EIR also "must include a description of the environment in the vicinity of the project, as it exists before the commencement of the project, from both a local and a regional perspective." CEQA Guidelines § 15125; *see also Environmental Planning and Info. Council v. County of El Dorado* (1982) 131 Cal.App.3d 350, 354. Here, the SEIR's deficiencies in describing the Project's setting undermine its adequacy as an informational document.

As discussed in more detail in the attached Kleinhaus Report, which is incorporated by reference, the SEIR fails to present important contextual information related to biological resources on the Project site and in adjacent areas along the Guadalupe River. This is important information from which to establish baseline conditions. Without a proper description of baseline conditions, the SEIR is unable to provide an adequate analysis of Project-related and cumulative impacts on biological resources compared to existing conditions.

As the Kleinhaus Report explains, despite the fact that the riparian and riverine habitat adjacent to the Project site is not pristine, it has relatively high value as a natural habitat area in an urban river environment where some upstream and downstream reaches has been compromised by development. Kleinhaus Report at 3. Even small natural habitat areas play an important role in conservation efforts. *Id.* Here, the SEIR underestimates the value of the riparian habitat on the Project site for hosting an abundant diversity of birds. *Id.* at 4. The site is recorded to host 95 bird species, many of which are migratory species. *Id.* The riparian forest is a healthy and robust forest, comprised of approximately 70 percent native species, along a relatively wide riparian stretch along the river. *Id.* at 5. The diversity of vegetation on site makes for a welcome refuge for migratory birds. The biological value of the site for birds is substantiated by the fact that the Guadalupe River Park Trail is one of the most popular, accessible sites for bird watching. *Id.* Therefore, the riparian area adjacent to the Project site provides valuable habitat in an urbanized area with few natural riparian habitat areas.

Because the SEIR characterizes the riparian area adjacent to the Project site as degraded and having only moderate value, the SEIR's evaluation of the Project's impacts on biological resources erroneously concludes that these impacts would be less-than-significant. Had the SEIR properly characterized the riparian habitat on-site, the SEIR would have concluded that Project impacts on this habitat related to shade and proximity of the massive structure, it would have concluded that impacts would be significant.

2. The SEIR Fails to Disclose the Extent and Severity of Impacts to Biological Resources Resulting from the Project's Shading Impacts.

The SEIR discloses that, based on the Downtown Strategy 2040 FEIR, development proposals within 100 feet of the riparian corridor of the Guadalupe River must assess the effects of the proposed development on riparian vegetation and creek temperatures. SEIR at 50. The SEIR explains that Projects that result in 20 percent or more increase in shade are required to alter their design to reduce shading. *Id*. The SEIR does not include a shade and shadow study to address this issue, but we presume the City is relying on the shadow study presented in the proposed Project's Initial Study analysis of impacts to natural sunlight on public open spaces. Initial Study Figure 4.11-1 at 88. The Initial Study concludes that Project impacts from shading of open space would be less-than-significant (*i.e.*, shade would not increase by 10 percent or more), but the Initial Study fails to quantify existing and proposed amounts of shade. *Id*. at 86 and 87. Without evidentiary support for this assertion, the City cannot conclude that shading increases will not exceed the City's adopted thresholds for shading on either public open spaces or on the river corridor, to trigger redesign of the Project.

Despite this lack of analysis, the shadow study depicts the Project's shade and shadow throughout the year under current conditions and with the proposed Project and shows that the Project would shade the riparian habitat on site "throughout all or most of the morning year-round." SEIR at 49. The SEIR discloses that this level of shading would potentially affect the health and growth of adjacent riparian plants. SEIR at 49 and 57 and SEIR Appendix D, Biological Resources Technical Report by H.T. Harvey at 8 and 9. However, the SEIR concludes, without analysis, that impacts associated with the Project's shading of riparian habitat will be less-than-significant. *Id*.

This conclusion is entirely unsupported. Neither the Initial Study nor the SEIR support the conclusion that increased shading will not harm adjacent riparian plants. Indeed, the evidence provided by the record supports the opposite conclusion—that the Project will harm the long-term viability of adjacent riparian vegetation. The SEIR should have evaluated this foreseeable environmental impact.

3. The SEIR Fails to Adequately Evaluate the Project's Adverse Indirect Impacts on Downstream Habitat Areas.

The SEIR fails to analyze the Project's potential to impact aquatic habitat downstream. The SEIR discloses that native fish, such as the Central California Coast steelhead and Central Valley Fall-run Chinook salmon are known to spawn, and special status fish such as Pacific Lamprey, green sturgeon, and longfin smelt may occur, in the Guadalupe River watershed. SEIR at 46. Despite these disclosures, the SEIR inexplicably omits analysis of the Project's potential impacts on downstream habitats except for one sentence stating that conditions in the Guadalupe River are less than optimal for fish habitat. *Id*. The SEIR fails to provide information on the locations where native fish are known to spawn or any details on where special-status fish might occur upstream or downstream.

This approach is contrary to CEQA requirements. Under CEQA, if an environmental impact is reasonably foreseeable, a lead agency has an obligation to disclose and analyze the impact as part of the CEQA process. CEQA Guidelines § 15064(d); *see also* CEQA Guidelines §§ 15065(a)(4) and 15358(a). CEQA defines a project-specific effect as *all the direct and indirect environmental effects* of a project. Public Resources Code § 21065.3; emphasis added.

The City has an obligation to disclose and analyze any and all Project-related impacts to habitat downstream (*i.e.*, resulting from degradation of water quality, increased erosion/siltation, etc.) and to native and special-status fish populations. This analysis must be completed now as part of this CEQA evaluation process rather than being deferred to an unspecified future date after the Project has been approved.

4. The Project's Approach to Mitigation of Impacts on Riparian Habitat is Inadequate.

Because the SEIR fails to adequately analyze significant impacts on biological resources impacted by project-related encroachment into the riparian area of the river, it also fails to provide adequate mitigation to address all of the ways that biological resources will be impacted. An EIR is inadequate if it fails to identify feasible mitigation measures, or if its suggested mitigation measures are so undefined that it is impossible to evaluate their effectiveness. *Lotus*, 223 Cal.App.4th 645; *San Franciscans for Reasonable Growth v. City and County of San Francisco* (1984) 151 Cal.App.3d 61, 79. The City may not use the inadequacy of its impacts review to avoid mitigation: "The agency should not be allowed to hide behind its own failure to collect data." *Sundstrom*, 202 Cal.App.3d at 306. The formulation of mitigation measures may not properly be deferred until after Project approval; rather, "[m]itigation measures must be fully enforceable through permit conditions, agreements, or legally binding instruments." CEQA Guidelines § 15126.4(a). Here, the SEIR's identification and analysis of mitigation measures, like its analysis of biological impacts, are legally inadequate.

The SEIR's approach to mitigating impacts to the riparian habitat is unacceptable for multiple reasons. First, the SEIR states that a Riparian Habitat Mitigation and Monitoring Plan is required to describe the mitigation planned for the site. SEIR at viii and 58-59. Yet, these important details are not included. It is critical that the mitigation plan be prepared now, prior to the City's approval, to ensure that all of the elements of the Project including the proposed mitigation, and reasonably foreseeable impacts, are evaluated for effectiveness and feasibility.

Second, as explained in comments submitted by both the San Francisco Bay Regional Water Quality Control Board ("Regional Board") and the Santa Clara Valley Water District, the proposed mitigation for impacts to the riparian habitat (i.e., Mitigation Measure BIO (C)-1) on site has not been shown to be feasible and no other mitigation has been proposed. First Amendment to the Draft SEIR Comment and Response C.2 and C.3 at 15-16 and Comment and Response E.5 at 20-21. The two commenting agencies stated that restoration of the riparian habitat on-site would require approval from the Water District, which does not typically allow private parties to implement such mitigation. Both agencies also requested verification that there are feasible opportunities for implementing the proposed 3.6 acres of riparian restoration and/or enhancement on the Santa Clara Valley floor in the City of San Jose. *Id*.

SEIR responses C.2, C.3 and E.5 reiterate the Project's proposed reduced setbacks and proposed mitigation measure, but never actually respond to the agencies' comments regarding the infeasibility of implementing the proposed mitigation measure. Under

CEQA, "an agency must solicit and respond to comments from the public and other agencies concerned with the project." *See* CEQA Guidelines §§ 15073, 15086-88 (emphasis added); *see also King and Gardiner Farms v. County of Kern* (2020) 45 Cal.App.5th 814, 882 (lead agency failed to provide reasoned response to EIR comment that proposed new mitigation measure). Here, the SEIR fails to adequately respond to these agencies' comments indicating that the proposed mitigation is infeasible.

The requirement of mitigation measures is at the core of CEQA. *See* Pub. Resources Code 21080(c)(2); *Citizens of Goleta Valley v. Bd. of Supervisors* (1990) 52 Cal.3d 553, 564. Mitigation measures ensure that an environmental document not only informs the public but charts a course to minimize a project's environmental impacts. Under CEQA, "public agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects." Pub. Resources Code § 21002.

Here, because the SEIR defers identification of impacts and defers preparation of enforceable mitigation plans, the EIR does not comply with CEQA. There cannot be meaningful scrutiny of an environmental document when the mitigation measures are not set forth at the time of project approval. *See Sundstrom*, 202 Cal.App.3d at 311 (1988) at 306-08. As such, the City must prepare a revised EIR for the Project to correct this egregious flaw.

5. The SEIR's Analysis and Mitigation of Impacts Related to Bird Collisions is Inadequate.

The SEIR discloses that the Project could create a potentially significant impact from birds colliding with the Project's high-rise glass structure. SEIR at 51. However, the SEIR identifies only three of the building facades as potentially impacting birds. *Id*. As the Kleinhaus Report explains, bird collisions in structures adjacent to riparian habitat are common on all facades of a building, regardless of their orientation relative to riparian areas. Kleinhaus Report at 8. By failing to account for the Project's full potential to cause bird collisions, the SEIR understates the Project's potential biological impacts.

In addition, the mitigation measures related to this impact are inadequate for several reasons. First, mitigation measure MM BIO-1.1 limits application of certain elements of the measure only to portions of the building at certain heights. SEIR at 51. As explained in the Kleinhaus Report, bird collisions can occur at any building height, including on the podium portion of the building. Kleinhaus Report at 8. Thus, mitigation would be necessary for the full height of the building.

Second, the proposed mitigation measures do not comply with the City's Downtown Design Guidelines and Standards ("DTDG"), which include bird safety guidelines and standards. *Id*. and DTDG at 49. The DTDG specifies that bird safety measures apply to all facades of buildings located within 300 feet of a riparian corridor, regardless of building orientation and whether or not a façade is visible from the riparian corridor. Kleinhaus Report at 8.

In addition, the proposed mitigation measures ignore bird safety requirements found in Council Policy 6-34 section 4, which states that:

> "[N]ew development should use materials and lighting that are designed and constructed to reduce light and glare impacts to Riparian Corridors. For example, the use of bright colors, and glossy, reflective, see through or glare producing Building and material finishes is discouraged on Buildings and Structures."

To ensure compliance with this policy, the mitigation measures should be revised to incorporate these requirements.

E. The SEIR's Analysis of the Project's Cumulative Impacts Is Incomplete and Flawed.

CEQA requires lead agencies to disclose and analyze a project's "cumulative impacts," defined as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts." CEQA Guidelines § 15355. A legally adequate cumulative impacts analysis views a particular project over time and in conjunction with other related past, present, and reasonably foreseeable future projects whose impacts might compound or interrelate with those of the project. Cumulative impacts may result from a number of separate projects, and occur when "results from the incremental impact of the project [are] added to other closely related past, present, and reasonably foreseeable probable future projects," even if each project contributes only "individually minor" environmental effects. CEQA Guidelines §§ 15355(a)-(b). Cumulative impacts analysis is necessary because "environmental damage often occurs incrementally from a variety of small sources [that] appear insignificant when considered individually, but assume threatening dimensions when considered collectively with other sources with which they interact." *Communities for a Better Env't v. Cal. Res. Agency* (2002) 103 Cal.App.4th 98, 114. *See also Kings County Farm Bureau*, 221 Cal.App.3d at 728-729 (EIR's treatment of cumulative impacts on water resources was inadequate where the document contained "no list of the projects considered, no information regarding their expected impacts on groundwater resources and no analysis of the cumulative impacts").

The SEIR concludes that the Project's encroachment into riparian habitat would result in a considerable contribution to significant cumulative impacts. SEIR Impact BIO(C)-1 at 57. Specifically, the SEIR's biological resources technical report states:

> "If encroachment is generally permitted along streams within the City of San José and/or VHP Habitat Plan Permit Area because the adjacent riparian habitat is determined to be moderate or low in quality, the encroaching developments will contribute to a significant cumulative impact by further reducing habitat quality throughout a large area" and "the contribution to cumulative impacts due to encroachment into the riparian buffer would be considerable for construction of the new building within this area, as it *represents a new type of development that will have a greater impact on the adjacent riparian corridor* (due to hemming in the riparian habitat and potentially reducing wildlife use of the adjacent portion of the river, shading riparian habitat and potentially affecting the health and growth of adjacent riparian plants, and bird collisions with new buildings, as discussed above) *compared to existing conditions*."

SEIR at 57 and SEIR Appendix D, Biological Resources Technical Report by H.T. Harvey at 8 and 9; emphasis added. While the SEIR comes to the correct conclusion, it fails to provide information on the extent and severity of the cumulative riparian area that will be affected and the efficacy of the proposed mitigation, so that the public and decision makers may reach their own conclusions. *Save Our Peninsula Committee v. Monterey County Board of Supervisors* (2001) 87 Cal.App.4th 99, 130.

Moreover, the SEIR fails to evaluate the cumulative impacts of shading of riparian habitat areas by the proposed Project in combination with the two 20-story, 297-foot office towers with a total building area of approximately 1.8 million square feet planned to the south of the Project site across Woz Way. The EIR for 280 Woz Way includes a shade and shadow study indicating that the Woz Way project will cast shade on the west bank of the river, opposite the Almaden Office Project, in the morning, year-round. Presumably, this shading would impact riparian plants similarly to the anticipated impacts disclosed for the proposed Project, doubly impacting riparian habitats. *See*, Shade and Shadow Study for 280 Woz Way, attached as Exhibit 4.

Nor can the SEIR cure its failure to analyze these impacts by rotely acknowledging the impacts' significance. As the Court of Appeal explained, "this acknowledgement is inadequate. 'An EIR should be prepared with a sufficient degree of analysis to provide decision makers with information which enables them to make a decision which intelligently takes account of environmental consequences.'" *Galante*

Vineyards v. Monterey Peninsula Water Mgmt. Dist. (1997) 60 Cal.App.4th 1109, 1123 (quoting CEQA Guidelines § 15151).

Here, although the SEIR concludes that cumulative impacts to riparian habitat would be significant, the SEIR fails to evaluate myriad indirect impacts to plant and wildlife along the length of the river, or quantify the magnitude of that impact when combined with the Woz Way project. SEIR at 3.6-9 and 3.6-10. A revised SEIR must evaluate impacts to all biological resources impacted and the analysis must account for both direct and indirect impacts.

VII. The SEIR Impermissibly Rejects the Identified Environmentally Superior Alternative.

A proper analysis of alternatives is essential to comply with CEQA's mandate that, where feasible, significant environmental damage be avoided. Pub. Resources Code § 21002 (projects should not be approved if there are feasible alternatives that would substantially lessen environmental impacts); CEQA Guidelines §§ 15002(a)(3), 15021(a)(2), 15126(f). Every EIR must describe a range of alternatives to the proposed project that would feasibly attain the project's basic objectives while avoiding or substantially lessening the project's significant impacts. Pub. Resources Code § 21100(b)(4); CEQA Guidelines § 15126(d). Therefore, the discussion of alternatives must focus on project alternatives that are capable of avoiding or substantially lessening the significant effects of the project, *even if such alternatives would impede to some degree the attainment of the project objectives* or would be more costly. CEQA Guidelines § 15126.6(b), emphasis added; *see also Watsonville Pilots Assn. v. City of Watsonville* (2010) 183 Cal.App.4th 1059, 1089 ("[T]he key to the selection of the range of alternatives is to identify alternatives that meet *most* of the project's objectives but have a reduced level of environmental impacts"); emphasis added.

As a preliminary matter, the SEIR's failure to disclose the extent and severity of the Project's broad-ranging impacts necessarily distorts the analysis of Project alternatives. As a result, the alternatives are evaluated against an inaccurate representation of the Project's impacts. Proper identification and analysis of alternatives is impossible until Project impacts are fully disclosed. Moreover, as discussed above, the document's analysis is incomplete and/or inaccurate so that it is simply not possible to conduct a comparative evaluation of the Project's and the alternatives' impacts.

The SEIR's Reduced Development Alternative 1 (Option 1) – Reduced Square Footage With 35-Foot Setback Alternative (which incorporates a 35-foot setback from the riparian habitat), was found to be the environmentally superior alternative "because it would reduce the significant construction air quality impact to a less than significant level and it would reduce the project's cumulatively considerable contribution to the Guadalupe River riparian corridor with implementation of Mitigation Measures BIO-1.1. This alternative would meet nine of the 10 project objectives." SEIR at 91.

The Planning Commission rejected the Reduced Development Alternative (Option 1), following staff's recommendation to deny it because "this alternative would not meet *one* of the project objectives, which is to maximize the use of an underutilized infill site compared to the Project." PC Staff Report, Item 5.a at 24; emphasis added. As discussed below, the proposed finding rejecting the Reduced Development Alternative (Option 1) does not comport with CEQA. PC Staff Report, Item 5.a at 12; PC Staff Report Appendix H Draft Special Use Permit Resolution at 15; and PC Staff Report Appendix I Draft Vesting Tentative Map Resolution at 6.

This approach is flawed for two reasons. First, the SEIR presents an overly narrow Project objective that effectively circumscribes and mandates selection of the Project or an alternative that is substantively similar. "[M]aximizing" the use of infill sites requires taking into account regulatory constraints. Therefore, the environmentally superior alternative *does* maximize the infill site, because it allows development to the maximum legal limit.[9]

CEQA requires agencies to explain their rejection of potentially feasible alternatives in a manner "sufficient to enable meaningful public participation and criticism." *Save Round Valley Alliance v. County of Inyo* (2007) 157 Cal.App.4th 1437, 1458. Courts have repeatedly found that agencies fail to meet this standard when they reject alternatives based on unsupported conclusions. *Save Round Valley Alliance*, 157 Cal.App.4th at 1465. To reject environmentally favorable alternatives, the agency must find that they either do not meet the project's objectives or that they are infeasible—that is, they are not "capable of being accomplished in a successful manner . . . taking into account economic, environmental, social, and technological factors." Pub. Resources Code § 21061.1. This finding must be supported by substantial evidence in the record.

CEQA mandates selection of the environmentally superior alternative if it can feasibly attain most of the project's objectives, "even if it would impede to some degree the attainment of the project objectives, or would be more costly." CEQA Guidelines § 15126.6(b). Moreover, any failure to meet project objectives is not grounds to reject an

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[9]To the extent that "maximizing" use of the site beyond regulatory constraints may result in more profit for the applicant, the applicant's profit motivation plays no role in decision making under CEQA. *See Save Round Valley Alliance v. County of Inyo* (2007) 157 Cal.App.4th 1437, 1460 ("[T]he willingness or unwillingness of a project proponent to accept an otherwise feasible alternative is not a relevant consideration.").

alternative where those objectives are too narrowly drawn. *See North Coast Rivers Alliance v. Kawamura* (2015) 243 Cal.App.4th 647, 669-70 (where the lead agency's overly narrow project purpose caused it to "dismiss[] out of hand" a relevant alternative, this error "infected the entire EIR"). As discussed, the environmentally superior alternative clearly satisfies the majority of the project objectives without impacting the riparian corridor to the same degree as the proposed Project. The proposed findings fail to include legitimate justification for rejecting the Reduced Development Alternative (Option 1).

Troublingly, the First Amendment to the SEIR shifts the reduced-scale alternatives to be setback from the property lines, not the edge of the riparian corridor. First Amendment to the SEIR (text revisions at 103) and Council Staff Report at 4. This is a substantial change from the reduced scale alternatives presented and analyzed in the SEIR, which would be consistent with City requirements for riparian setbacks. SEIR at 88. Riparian setback requirements, as set forth in the City's Riparian Corridor Policy Study, and as confirmed by City staff, make clear that the relevant development setback measurement is not from edge of the property line, but from the edge of the riparian drip line. Policy Study at 31; Council Staff Report at 6.

The Riparian Setback Diagram, attached to the Council Staff Report, shows measurements from various points of the proposed Project (Building or L1F&B/Amenity; L2 Tower Above; and Basement Underground) where the property line encroaches into the riparian habitat for most of the length of the proposed Project site.[10] The proposed change in measurement is irrational given that staff evaluated the proposed Project setback as measured from the edge of the riparian corridor." Council Staff Report at 4. The SEIR likewise indicates that for the Reduced Development Alternative 1 (Option 1) – Reduced Square Footage With 35 Foot Setback '[T]he proposed building would be set back from the Guadalupe River riparian corridor by 35 feet." SEIR at 88. The Council Staff report also states that "staff evaluated the setback as measured from the edge of the riparian corridor." Council Staff Report at 4. The Council Staff Report further clarifies

[10]For purposes of considering whether the proposed Project would be consistent with required setbacks and for evaluating foreseeable impacts, the most relevant measurement is from the riparian edge to the basement line. This is because: 1) relevant City policies measure the required riparian setback from the riparian edge to the edge of development, and 2) impacts to the riparian habitat occur above and below ground. Excavation and construction of the basement/underground parking garage would damage tree and plant roots, impacting their ability to thrive. According to the Riparian Setback Diagram, in the case of the proposed Project, the development would take place within 1 foot 6 inches (1'6") of the riparian edge.

that "[F]or this project site, the edge of the vegetation is the edge of the riparian corridor." *Id*. Therefore, it is abundantly clear that when the EIR contemplates riparian setbacks, the measurement is assumed to be made to the edge of the riparian corridor defined by the edge of vegetation.

This late change to the Project alternatives means that the SEIR failed to fully analyze impacts on the riparian habitat. That is, an analysis of impacts with the measurement from the edge of the riparian corridor would necessarily find that impacts would be less than an analysis of impacts with the measurement from the property line. This is because the latter scenario allows for significant encroachment into riparian area compared to an alternative that measures the setback from the edge of riparian corridor.

Significantly, the alternatives revision in the First Amendment to the SEIR means that the SEIR fails to consider any alternative that is consistent with the City's setback requirements as set forth in the Riparian Corridor Policy Study, Council Policy 6-34, and the City's General Plan. This approach violates CEQA. *Banning Ranch*, 2 Cal.5th at 936-37 (an EIR's consideration of alternatives must account for constraints placed on a project by "other plans or regulatory limits"). Further, the SEIR fails to evaluate the alternatives' impacts related to their inconsistency with the City's riparian setback policies.

Lastly, with this change, aside from the required No Project Alternative, the SEIR also only considers one alternative that complies with City policies - Reduced Development Alternative 2 – Square Footage Reduction and Increase in Height, which would allow a building up to a maximum height of 30 stories. But here too, the EIR is flawed because it never evaluates shade and shadow impacts of constructing a building to such height. SEIR 90-91. In short, the SEIR's alternatives analysis is riddled with flaws that both improperly constrain to the City's consideration of project alternatives, and prevents the City Council from fully grasping the advantages and disadvantages of the listed alternatives.

VIII. Conclusion

This Project cannot be approved in its present form. It contains substantial conflicts with the City's General Plan and other mandatory policies. At the same time, the SEIR is legally inadequate and cannot serve as the basis for Project approval. For these reasons, the Sierra Club requests that the Council deny the Project. Alternatively, if the Council opts to proceed with the Project, we request that you modify the project so that it is consistent with all applicable requirements, including an adequate riparian setback, and would not result in significant impacts on the adjacent riparian habitat.

Very truly yours,

SHUTE, MIHALY & WEINBERGER LLP

[redacted]

Edward T. Schexnayder

[redacted]

Carmen J. Borg, AICP,
Urban Planner

Attachments:

Exhibit 1 – MBK Engineers Report, September 9, 2021
Exhibit 2 – Shani Kleinhaus Report, September 9, 2021
Exhibit 3 – Santa Clara Valley Water District Bank Protection/Erosion Repair Design Guide
Exhibit 4 – Shade and Shadow Study for 280 Woz Way

cc: Agendadesk@sanjoseca.gov
Mayor Sam Liccardo, mayoremail@sanjoseca.gov
Vice Mayor D1 Charles "Chappie" Jones, District1@sanjoseca.gov
D2 Sergio Jimenez, District2@sanjoseca.gov
D3 Raul Peralez, District3@sanjoseca.gov
D4 David Cohen, District4@sanjoseca.gov
D5 Magdalena Carrasco, District5@sanjoseca.gov
D6 Devora "Dev" Davis, District6@sanjoseca.gov
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D8 Sylvia Arenas, District8@sanjoseca.gov
D9 Pam Foley, District9@sanjoseca.gov
D10 Matt Mahan, District10@sanjoseca.gov
Robert.Manford, Robert.Manford@sanjoseca.org
Chris.Burton, Christ.Burton@sanjoseca.gov
James Eggers, [redacted]
Bruce Rienzo, [redacted]
Mike Ferrera, [redacted]

Barbara Kelsey, [redacted]
Gladwyn d'Souza, [redacted]
David Poeschel, [redacted]
Katja Irvin, [redacted]

1409422.7

EXHIBIT 1

Water Resources ◆ Flood Control ◆ Water Rights

TECHNICAL MEMORANDUM

DATE:	September 10, 2021
PREPARED BY:	Ric Reinhardt, P.E., MBK Engineers
TO:	Carmen Borg, Shute, Mihaly & Weinberger LLP
SUBJECT:	Review of Supplemental Environmental Impact Report for Almaden Office Project

MBK Engineers was tasked with reviewing the Supplemental Environmental Impact Report (SEIR) and Initial Study (IS) for the Almaden Office Project in San Jose, California. The focus of the review regards the hydrology, groundwater, and water quality sections of the SEIR. This technical memorandum documents my comments regarding the subject document.

COMMENTS

1. Comments on hydrology and flood management:
   A. The IS concludes that because the project is not in the Federal Emergency Management Agency (FEMA) 100-year floodplain, there are no restrictions on development. In reviewing the FEMA effective Flood Insurance Rate Map for the project area, the project site is mapped into a shaded Zone X and the surrounding area is mapped in a Zone D. Shaded Zone X is defined as an area at risk of flooding for events greater than 100-year, but less than 500-year. Zone D is defined as an area of undetermined flood risk.

   B. Using FEMA's flood insurance requirement for the 100-year floodplain is inconsistent with State and Federal recommendations regarding the management of flood risk, especially when considering the risk that climate change will result in an increased frequency and intensity of extreme flood events.
      i. Federal guidance on development of the floodplain is contained in Executive Order (EO) 13690, which established a Federal Flood Risk Management Standard (FFRMS). EO 13690 amended the existing EO 11988. EO 11988 governs Federal actions in floodplains. It encourages wise use of the floodplain, and is used in guiding decisions on Federal investment in order to minimize the risk of flood damages in the future. The FFRMS is a more conservative standard than the FEMA flood insurance standard of the 100-year flood, and FFRMS relies on several methods to consider flood risk, including increases in flooding due to climate change and use of the 500-year floodplain, along with other options, to inform investment decisions to reduce the risk of flood damages and loss of life. EO 13690 also encouraged consideration of natural systems, ecosystem processes, and nature-based approaches.

ii. State guidance on development in the floodplains is documented in the California Water Resiliency Portfolio and the California Flood Future Report.

a. The Water Resiliency Portfolio was prepared by the California Resources Agency with support from other State agencies and stakeholders. It is a framework for actions the State and local agencies should take to prepare for a warming climate. With respect to floodplain management, the following statements are relevant: Page 14 – Flood Risk, "Avoiding floodplain development and allowing rivers to regain access to floodplains can help manage floods while benefiting water supplies and fish and wildlife habitat." Page 81 of appendix 3 section 2 – "Winter storms [are] more intense – a once-in-20-year storm will become a one-in-seven year or more frequent storm." And "Dry and wet extremes will increase."

b. The California Flood Futures Report was prepared by the California Department of Water Resources (DWR) and the U.S. Army Corps of Engineers (USACE) in 2013. "California's Flood Future is provided to help inform local, State, and Federal decisions about policies and financial investments to improve public safety, foster environmental stewardship, and support economic stability." Section 2.3.2 of this report states: "Land Use Planning employs policies and practices to limit development in flood-prone areas and encourages land uses that are compatible with floodplain functions. This can include policies and practices that restrict or prohibit development within floodplains, restrict size and placement of structures, prevent new development from causing adverse flood impacts to existing structures, encourage reduction of impervious areas, require floodproofing of buildings, and encourage long-term restoration of streams and floodplains." Page 4-5 of the report states, "Some short-term actions, such as the following, do not require substantial additional financial resources: Land use planning and decision making must consider flood management. This includes limiting development in floodplains."

C. While it is accurate to state that there are no restrictions on development in a FEMA shaded Zone X, by approving a project within 35 feet of the top of the streambank, there is insufficient right of way to respond to flood management concerns in the future. For example, if the 100-year flow increases as forecasted with climate change, or if the City or Valley Water decide to provide higher levels of protection, a floodwall would likely be needed. Construction of a floodwall would require removal of a significant portion of the riparian corridor because the development is not setback far enough from the top of the streambank. Urban areas across the State and the nation have long recognized the need for higher levels of protection than what is provided in FEMA's minimum 100-year. For example, cities in the California Central Valley have a 200-year standard, including Lathrop, Stockton, Manteca, Sacramento, West Sacramento, Woodland, Yuba City, and Marysville. Meanwhile, communities in Sacramento and Yuba counties are attempting to pass the 500-year flood in their urban areas. Allowing development within 35 feet of the top of bank will increase the costs of providing flood protection and would likely require the removal of significant portions of the riparian corridor in order to construct a floodwall and install bank protection to protect the project site from flooding.

State guidance regarding the development of setbacks is contained in the State of California's Urban Levee Design Criteria (ULDC). Section 7.11 of this document states:

> "Right-of-Way [1]criteria for levees and floodwalls in urban and urbanizing areas need to meet the following objectives: Allow adequate room for maintenance, inspection, patrolling during high water, and flood-fighting. To the extent practical, adequate right-of-way should be available to provide additional room to expand facilities in the future. Reasons to expand the facilities might include:
>
> - Desire by the community to provide higher levels of flood protection.
> - Changes in design criteria, poor performance during high water, updated hydrology and/or hydraulics, or other data that would indicate that additional modifications are necessary to maintain the urban level of flood protection."

Right-of-Way for Long-Term Flood Protection in Section 7.11.2 states:

> "In order to meet the second objective, the city, county, or levee maintaining agency should consider acquiring right-of-way for a future needs area that has a width equal to at least four times the levee height or 50 feet, whichever is greater, on the land side of the 20-foot clear zone. If acquired:
>
> - Structures should not be constructed in this future needs area.
> - It must also be understood that some seepage is normal and acceptable during high water, so uses incompatible with this seepage should not be allowed in this area. The future needs area may be used for open space, agriculture, bike and pedestrian trails, outdoor recreation, parking lots, or other similar uses not likely to have an adverse impact on the structural integrity of the levee or floodwall, but with the understanding that these facilities may be displaced by future levee construction."

Conclusion: Allowing development within 35 feet of the river without an adequate setback/buffer is shortsighted land use planning and will restrict how local agencies respond in the future to mitigate changes in flood risk. Placing the proposed project so close to the Guadalupe River increases the likelihood that undeveloped portions of the riparian corridor will need to be replaced with flood protection measures in the future.

[1] Right way in this application is defined as the footprint needed for the flood control structure and adequate operation and maintenance corridors on the water and landside of the structure.

D. The IS and SEIR do not evaluate the impacts of climate change on hydrological conditions surrounding the project site. The specific concern regards how climate change may increase the intensity and/or frequency of extreme flood events. The most likely effect being increased areas along the river being mapped into the FEMA 100-year floodplain. EO 13690, the Water Resiliency Portfolio, and the Flood Futures Report all highlight the need to plan for increased extreme flood events in the future due to climate change. Valley Water's Climate Change Action Plan states, "Precipitation could increase in overall volume. Extreme heat and precipitation events are likely to increase in frequency." Section 2.2.2 of the report states that, "Floods may become more likely as a result of increasing precipitation intensity, extreme storm events, and [sea level rise] (Ackerly et al., 2018)."

Section 2.2.2.1 states:

> "River flooding, also called fluvial or riverine flooding, occurs when rainfall intensity or frequency causes a river to exceed its capacity. Climate change will affect the level of river flood risk since existing flood protection projects have been designed considering statistical analysis of past events and are built to provide protection to a certain level—often the one percent flood (1-in-100 chance or 1% probability) of being equaled or exceeded in any given year. Climate change impacts on the frequency and severity of fluvial flooding are difficult to predict with certainty. Most models project more intense storms, and possibly increased return frequencies. Using IPCC data, (Ackerly et al.,2018) projected that a 20-year return frequency one-day storm event for the Bay Area would increase in frequency by a factor of three or more by end of century, becoming a once-in-seven year storm rather than a once-in-20-year storm. The level of protection provided by previously built flood protection infrastructure may be insufficient if hydrologic conditions vary from design assumptions, as a result of climate change."

Section 3.2.2.1 states:

> "As it is likely that the frequency of extreme precipitation events will increase by mid-century, Santa Clara County is at a higher risk of storm-related flooding. This has the potential to damage public and private infrastructure, coastal and riverine habitat, and public safety. Existing flood protection facilities are vulnerable to climate-related events such as extreme storms and wildfires. For example, creek channels in the county, which are maintained to provide adequate flow capacity, can become clogged with sediment and debris following a wildfire, decreasing capacity to pass flood flows."

Conclusion: The proposed project is placing lives and damageable property at risk without planning for a way to address the increased flows that Valley Water, DWR, and USACE are predicting will result from climate change. This should be addressed in Section 5 of the SEIR as a Significant and Irreversible Environmental Change. The SEIR should also describe the foreseeable flood-protection measures that the proposed project would require to prevent flooding of the project site.

E. The existing streambank does not have bank protection. A review of the site photos (Attachment A) shows areas of minor erosion. Overtime, the natural riverine geomorphic processes are expected to result in increased erosion at the project site as river channels naturally meander and erode their existing banks. With the proposed development being 35 feet from the top of bank, a hard scape solution will likely be required to protect the building. Construction of a hardscape solution, such as riprap, will require removal of the riparian vegetation for construction to create a stable slope to place the riprap. Installation of riprap or similar bank protection methods will establish a hard point at the project site, and risks increasing erosion up and downstream of the site by increasing and/or redirecting velocities.

   Attachment B includes images from Google Earth showing the project site and the reaches of the Guadalupe River upstream and downstream of the project site. The images show that in 1993 there was very little bank protection or hardscaping of the riverbanks, and the riparian corridor was largely intact. However, in comparing the 1993 images to current images, as the area developed, the riverbanks have been hardened with concrete terraces, riprap, and other hardscape features.

   Conclusion: If the setback was increased, it would allow for more flexibility in permitting the natural riverine processes to occur, and would provide more flexibility in addressing erosion in ways that preserve the existing riparian vegetation without having to construct hardscaping to address erosion at the project site. This should be addressed in Section 5 of the SEIR as a Significant and Irreversible Environmental Change.

2. Comments on groundwater analysis:

   A. Appendix F of the SEIR is the Geotechnical Engineer's Report. This report identifies a sand layer that is at a similar depth to that of the Guadalupe River's riverbed. The report identifies alternatives for addressing groundwater during construction, but does not specify which alternative will be used during construction. The SEIR does not state whether there will be permanent groundwater pumping or other features installed to permanently alter groundwater flow at the site. Section 6.2 of Appendix F states that, "Drainage should be collected by perforated pipes and discharged by gravity or directed to a sump(s)." However, it is not clear whether this is a temporary construction action or a long-term feature of the project. If permanent groundwater pumping occurs, it could reduce flows into the Guadalupe River, and negatively affect the river system or it could cause subsidence around the project site.

   B. Valley Water's comment E.8 states:

      "Valley Water recommends that the construction dewatering system be designed such that the volume and duration of dewatering are minimized to the greatest extent possible. Valley Water also recommends that a more detailed analysis of construction dewatering be conducted, including estimating dewatering volumes/durations and evaluating related impacts."

However, the response to this comment simply refers the commentor to Appendix F, which does not identify the specific dewatering system and construction shoring method that will be used to address this concern.

Conclusion: The SEIR does not identify the method of excavating the foundation of the building or the associated dewatering plan that will be used, only options that could be considered. As a result, the SEIR does not demonstrate that the method of construction will not adversely impact the river or the surrounding aquifer.

3. Comment on Water Quality Section of the IS:

The IS identifies the regulatory requirements and the process for meeting water quality requirements. However, the IS does not specify how certain portions of the project will comply with these regulations. For example, there is not a description of the methods that will be used to treat the groundwater removed by the dewatering system, or a description of exactly where the point of discharge of the treated groundwater will be. The long-term treatment plan and point of discharge for the drains that are proposed are also not specified.

Conclusion: The IS and SEIR do not identify the specific methods that will be utilized to meet water quality requirements during construction. As a result, the IS and SEIR do not disclose how the chosen methods will meet the regulatory requirements; they simply assert requirements will be met, and can be accomplished through a range of alternatives.

[redacted]

Ric Reinhardt, P.E.

Attachments: Bank Erosion Site Photos
Google Earth Images of Bank Protection Over Time
Ric Reinhardt Resume

1412743.2

Attachment A.
Bank Erosion Site Photos

Photo No. 1.

Photo No. 2.

Photo No. 3.

Photo No. 4


Neighborhood Work
Stream Maintenance Program
Valley Water
Stream Maintenance Program
The Santa Clara Valley Water District (Valley Water) performs work annually under its Stream Maintenance Program to repair damages to creeks to reduce the risk of flooding and keep our communities safe.
Bank protection work is underway
High flows can cause extensive damage to creek banks, eroding existing flood protection improvements and natural elements. Repairing creek banks helps protect neighboring homes and property from damage.
Timing
State and federal regulatory agencies limit bank protection projects to occur between June 15 through October 15 in order to protect creek habitat and wildlife. In some instances, Valley Water may receive work extensions beyond October 15 to complete projects.
Work hours, set according to local city ordinances, are from 8 a.m. to 5 p.m. Monday through Friday. Some projects may require Saturday work or a start time of 7 a.m. Any work before 8 a.m. will be limited to preparation activities with minimal noise impact.
What to expect during work hours
Work hours, set according to local city ordinances, are from 8 a.m. to 5 p.m. Monday through Friday. When warranted, construction activities could occur on Saturdays or have a start time of 7 a.m. Any work before 8 a.m. will be limited to preparation activities with minimal noise impact.
Contact us
For more information on the Stream Maintenance Program, please visit our website at https://delivr.com/2gpuq.
For project related questions, please contact: Mike Sawatzky at (408) 630-3761 or email at msawatzky@valleywater.org.

Photo No. 5.

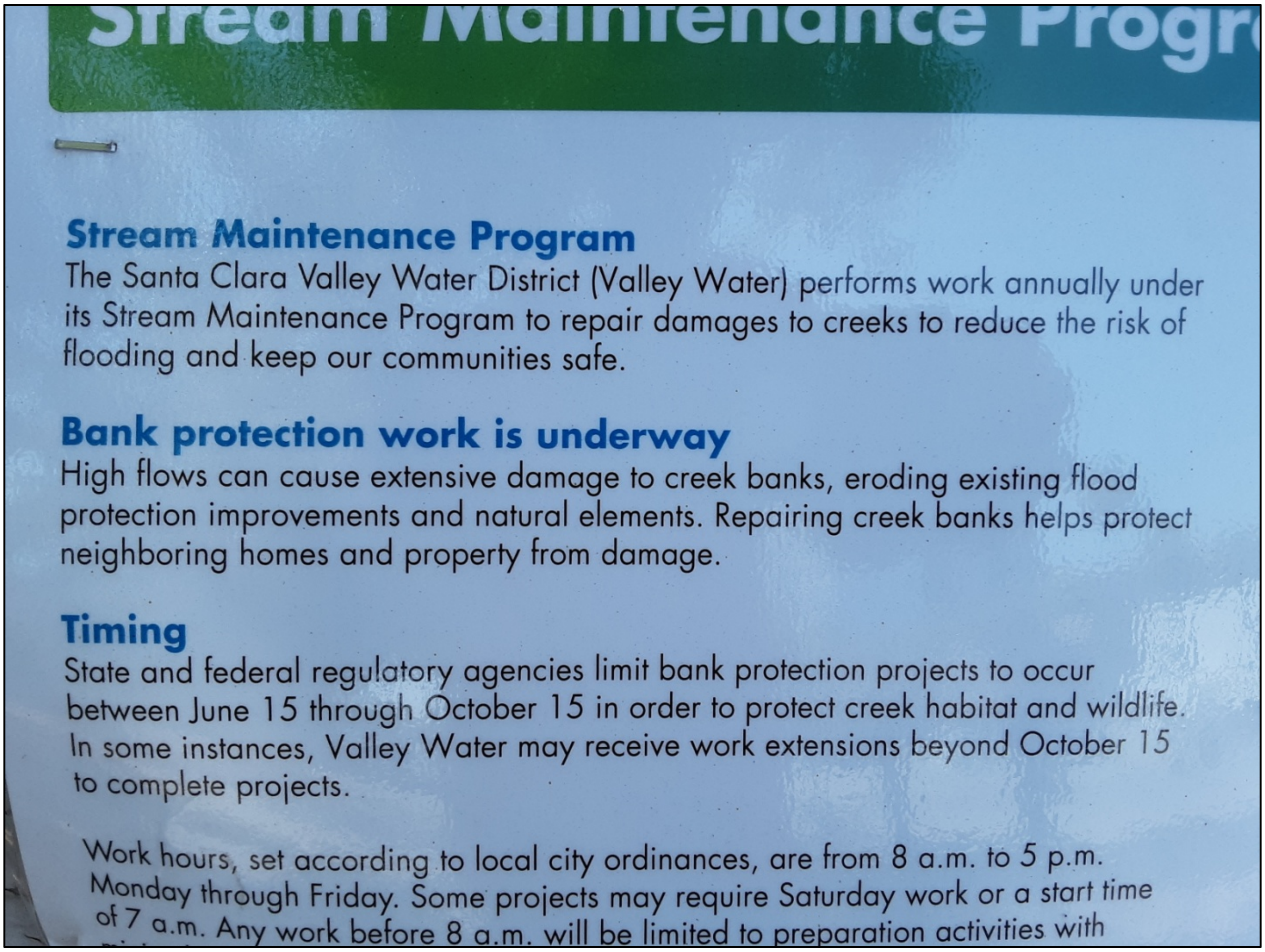
Stream Maintenance Progr
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Photo No. 6.

Photo No. 7.

Photo No. 8.

Photo No. 9.

Photo No. 10.

Photo No. 11.

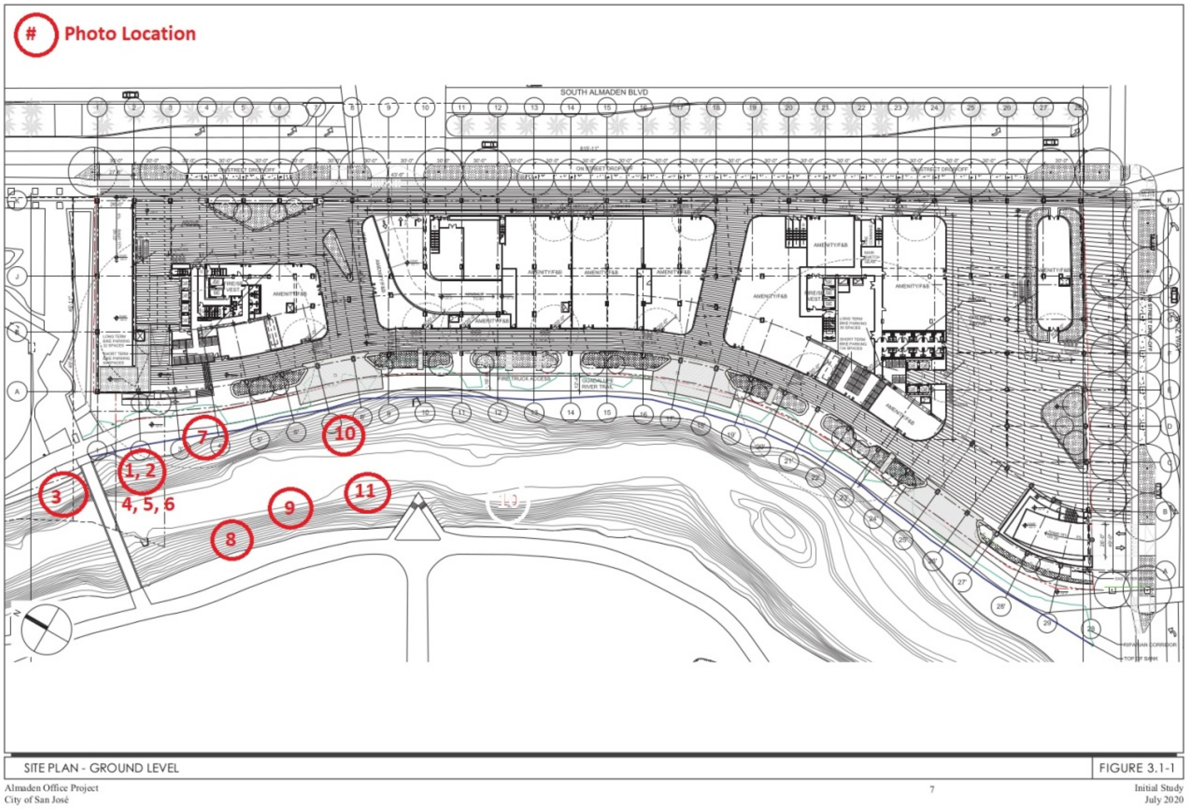


Photo Location
SOUTH ALMADEN BLVD
1, 2
4, 5, 6
3
7
8
9
10
11
SITE PLAN - GROUND LEVEL
FIGURE 3.1-1
Almaden Office Project
City of San José
7
Initial Study
July 2020

Photo No. 12.

Attachment B.
Google Earth Images of Bank Protection Over Time

Plan view of reach between Woz Way and Highway 280 (Google Earth June, 1993)

Without Bank Protection

Plan view of reach between Woz Way and Highway 280 (Google Earth Aug, 2020)

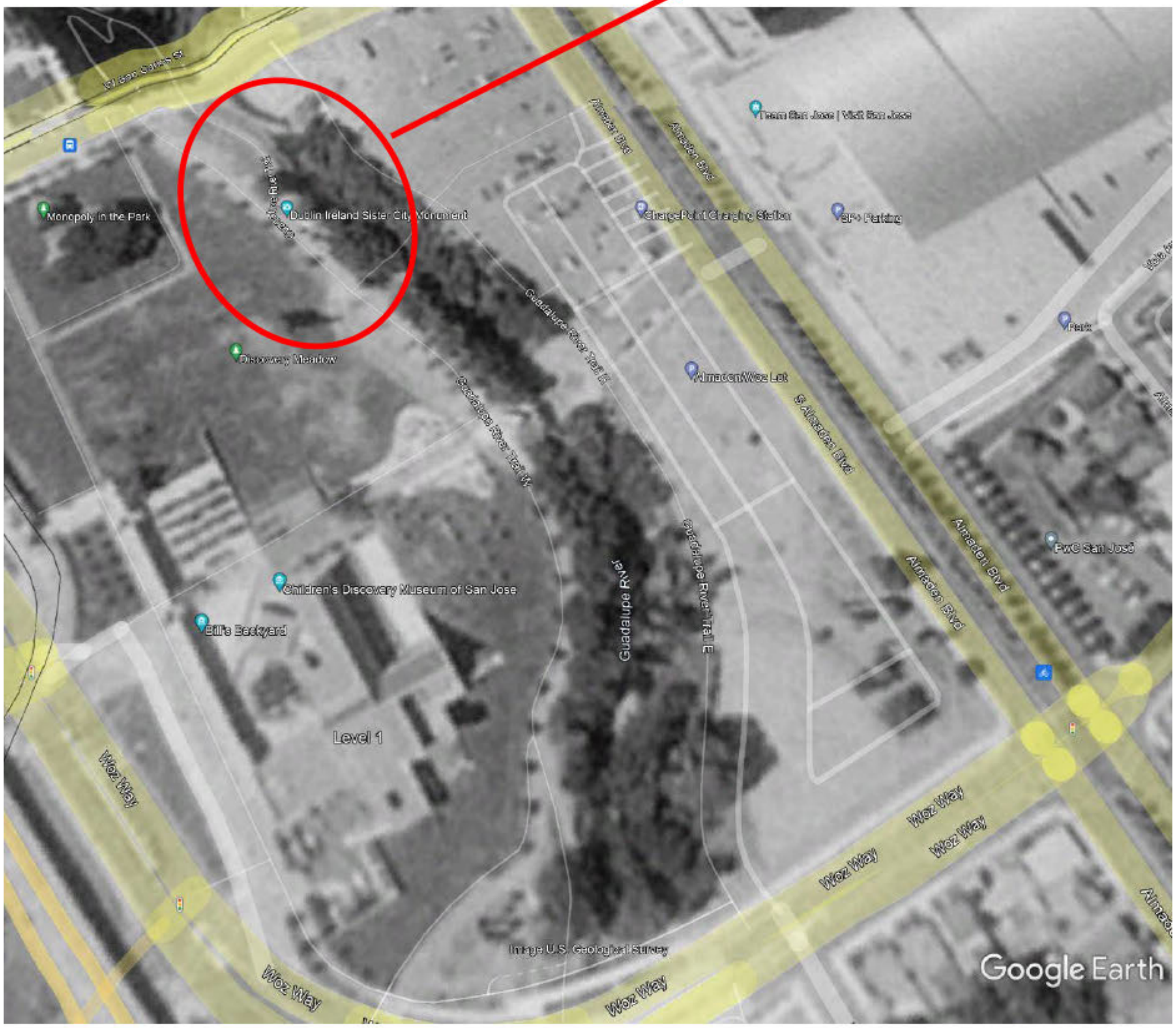
With Bank Protection

Looking upstream at Highway 280 (Google Earth Aug, 2020)

Highway 280 looking downstream (Google Earth Aug, 2020)

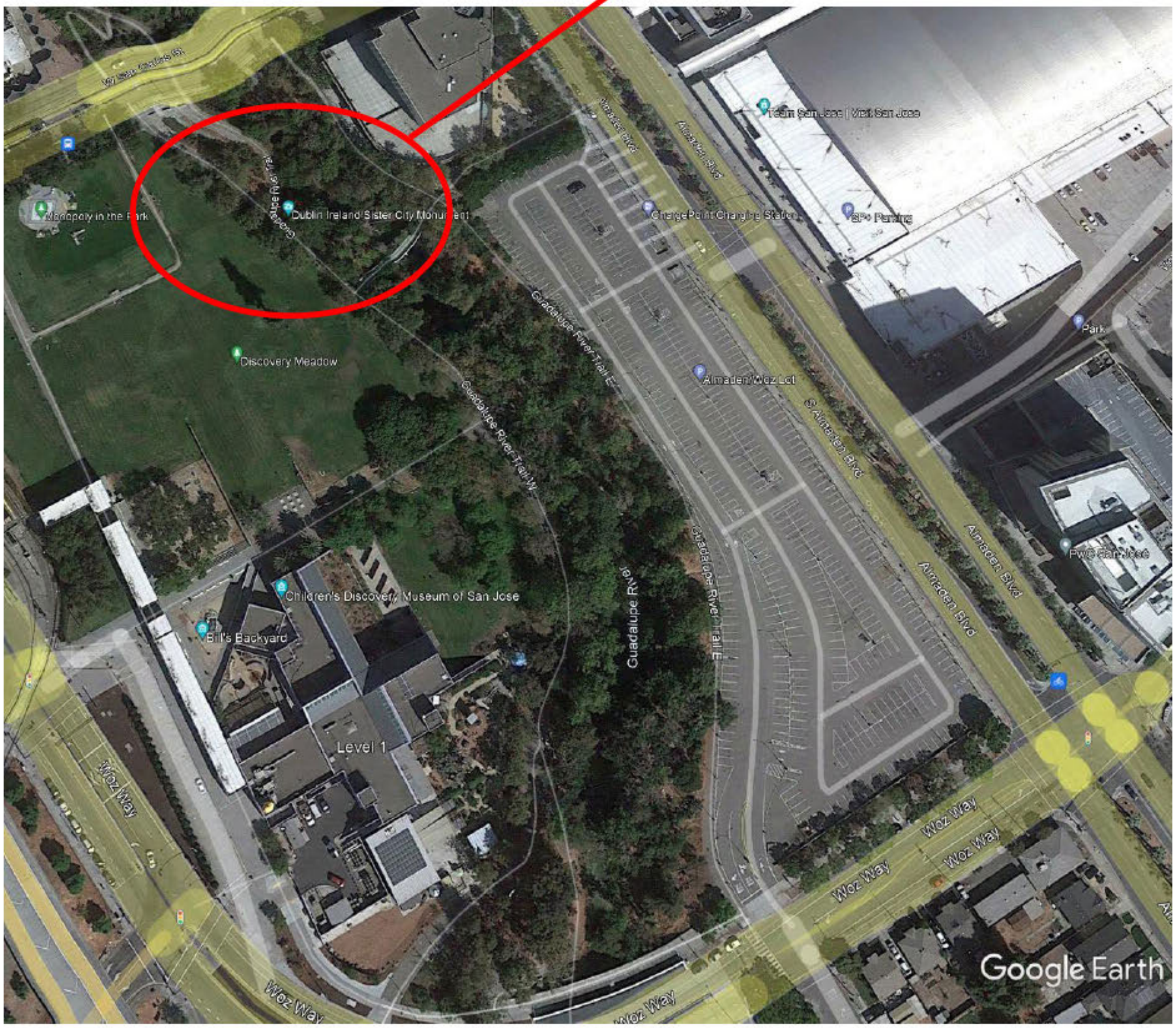
Without Bank Protection

Project site (Google Earth June, 1993)



With Bank Protection

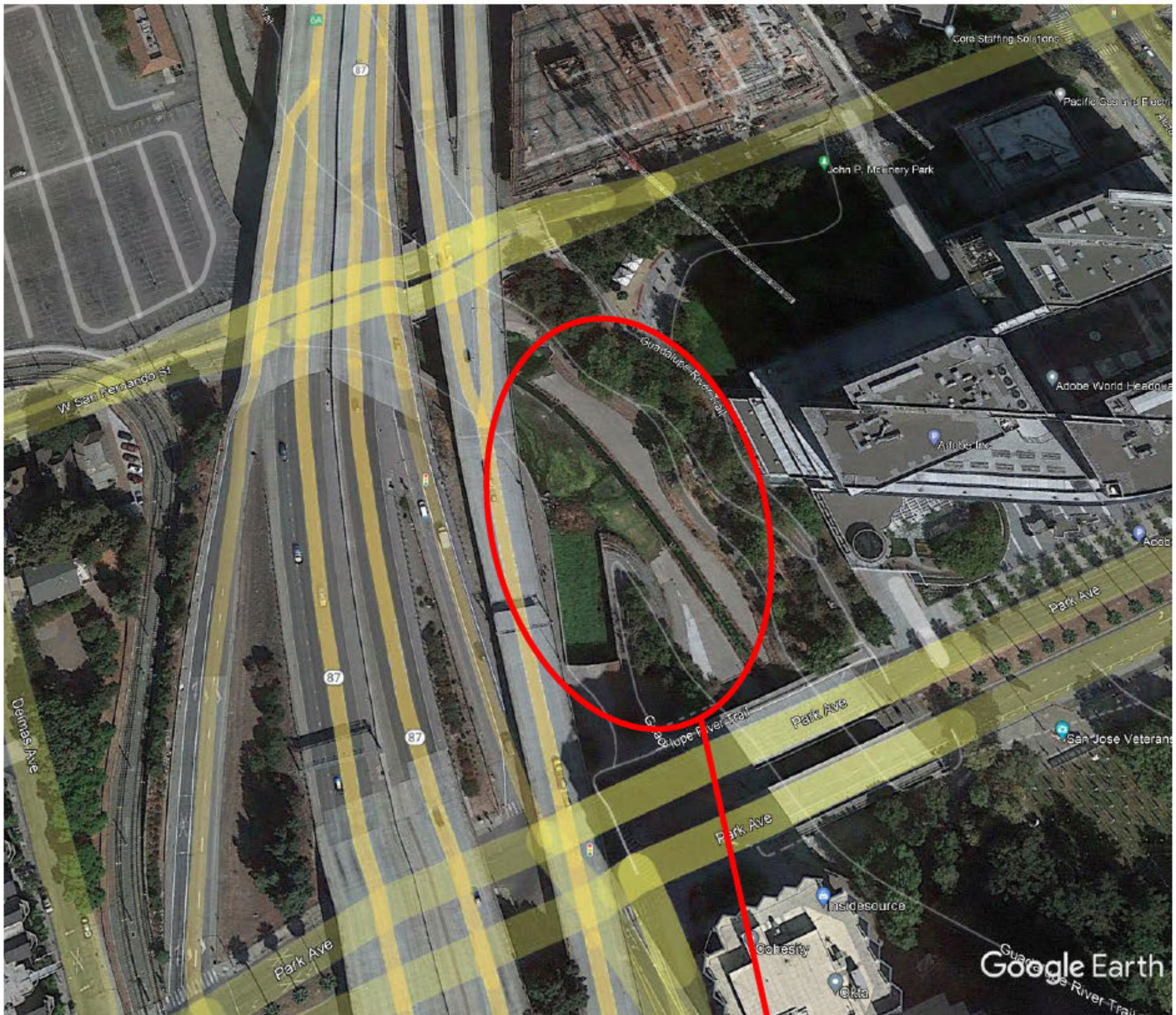
Project site (Google Earth Sept, 2020)



Park Ave. to W San Fernando St. (Google Earth June 1993)

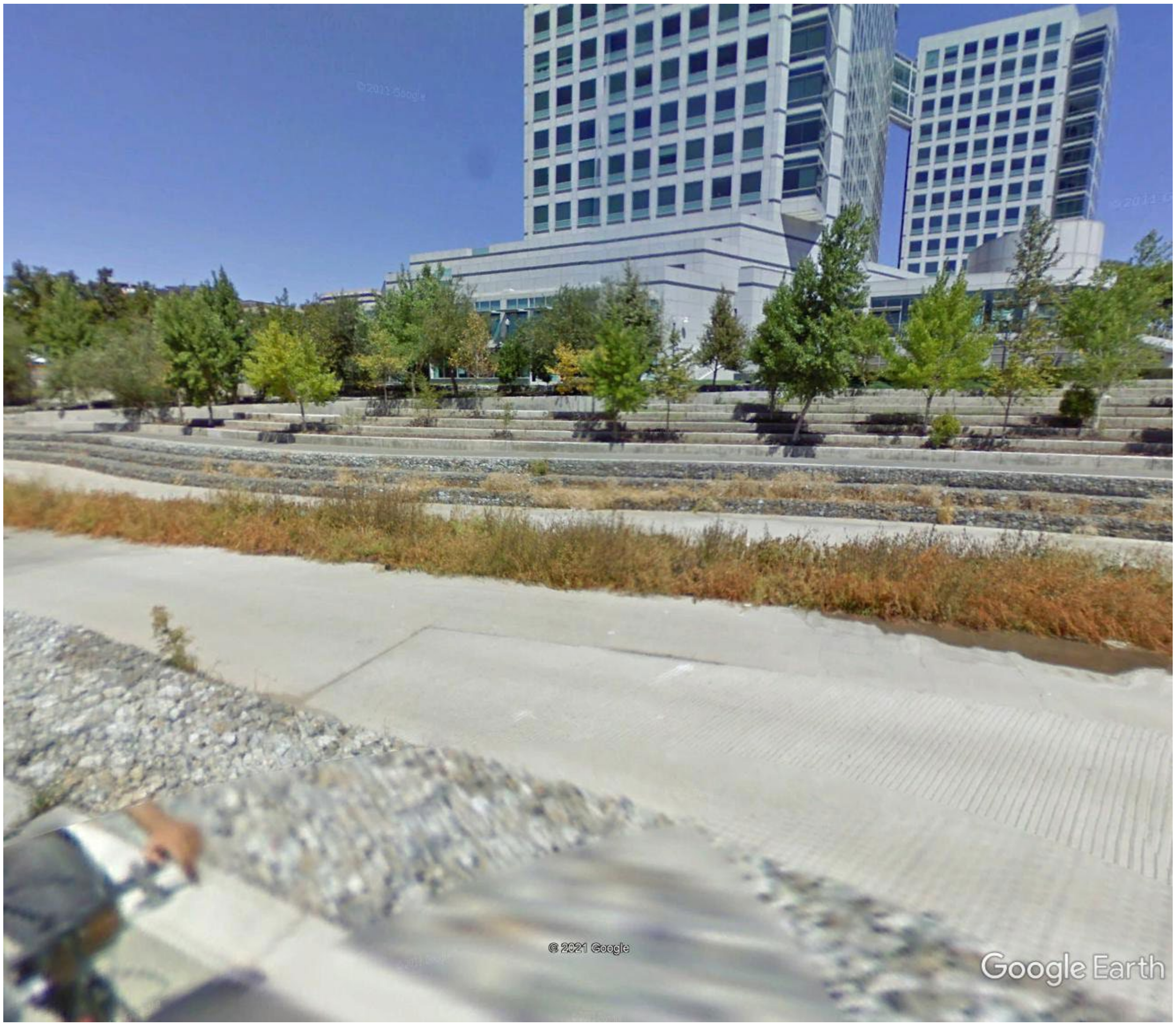
Without Bank Protection

Park Ave. to W San Fernando St. (Google Earth Sept 2020)



With Bank Protection

Park Ave. to W San Fernando St. looking east (Google Earth Sept 2020)



Attachment C.
Ric Reinhardt MBK Engineers Resume

Ric Reinhardt

Principal Engineer

Ric Reinhardt is a Principal with MBK Engineers and provides policy and project support for a variety of rural and urban clients. Ric oversees feasibility studies, NEPA/CEQA compliance, permitting, design for both urban and rural levees systems, construction, and real estate acquisition. The majority of these projects have required permission to alter Federal project levees, as required by 33 U.S.C. Section 408.

Prior to joining MBK, Ric worked for the USACE, Sacramento District where he served in several different capacities, including as Lead Engineer and Senior Project Planner. Most of his experience is in planning and design of flood damage reduction and ecosystem restoration projects.

EDUCATION

California State University, Sacramento
Master of Science
Civil Engineering, 1998

California State University, Sacramento
Bachelor of Science
Civil Engineering, 1996

REGISTRATIONS

Registered Civil Engineer California
License No. C060093

Registered Civil Engineer Louisiana
License No. 0041672

PROFESSIONAL MEMBERSHIPS

Member, American Society of Civil Engineers

PROFESSIONAL SKILLS

Policy and Legislative Support

Expert Witness

RELEVANT EXPERIENCE

California Central Valley Flood Control Association (CCVFCA)

Engineer for the CCVFCA. Provides policy and legislative support on State and Federal flood management regulations and laws. Supports the appropriations process for state flood management funding.

Rural Reclamation District Support

District Engineer for several rural Reclamation Districts. Responsible for developing budgets, scheduling O&M activities, repairs to levees, supporting 218 elections, pursuing grant funding and engaging on policy and legislative flood management issues effecting rural areas.

Three Rivers Levee Improvement Authority

Program manager for the Three Rivers Levee Improvement Authority. Responsible for planning, design, and construction of a $500 million levee improvement program to provide 200-year protection to South Yuba County.

Sacramento Area Flood Control Agency

Has served as a program manager for the Sacramento Area Flood Control Agency on several large-scale flood management projects. Performs role as certifying engineer for both FEMA and Urban Levee Design Criteria for the levees systems protecting Sacramento.

Lower Cache Creek Feasibility Study

Project manager for the City of Woodland's Lower Cache Creek Feasibility Study. This is a USACE Civil Works Feasibility Study. Responsible for providing planning and engineering support to the Study team and overseeing work in kind being performed by the non-federal sponsors.

Lower Sacramento River/Delta North Regional Flood Management Plan

Responsible for identifying projects and building support for a regional vision of flood management in the area surrounding the Yolo Bypass.

MBK ENGINEERS

EXHIBIT 2

SCVAS
Santa Clara Valley
Audubon Society

September 7, 2021

Carmen Borg
Shute, Mihaly &Weinberger LLP
396 Hayes Street
San Francisco, CA 94102

Re: Review of Almaden Office Project, First Amendment to the Draft SEIR

On behalf of the Santa Clara Valley Audubon Society and the Sierra Club Loma Prieta Chapter, I have reviewed the City's Supplemental Environmental Impact Report ("SEIR") for the Almaden Office project. The Project proposes to construct a 16-story building immediately adjacent to the Guadalupe River without an adequate setback to buffer the riparian area from construction and operation impacts and increased human activity.

I am a biologist with over 30 years of expertise in avian research and protection in urban habitats and beyond. I earned my Ph.D. degree in Ecology from the University of California at Davis. I subsequently conducted post-doctoral research at the Ben Gurion University of the Negev in Beersheba, Israel focusing on the hazards of man-made structures to migratory birds. I also conducted post-doctoral research focusing on watershed master planning efforts and on restoration of creek corridors in rural and urban landscapes at Tel Aviv University in Tel Aviv, Israel.

Upon completion of my post-graduate work, I worked as the lead biological consultant to the Israeli River Restoration Authority and to the Israeli National Park Authority. For over ten years, I have been the Environmental Advocate for Santa Clara Valley Audubon Society, and have provided professional consulting services related to bird collisions with glass buildings, native plantings and habitat creation. Through my employment with Audubon, as well as through independent consulting work, I have worked with Intuit, Facebook, Google, CBRE (CB Richard Ellis), Cushman and Wakefield, and other companies to help monitor, evaluate and incorporate adequate bird safety measures, lighting, and glazing treatments in new construction and retrofitted buildings and native habitat protection and enhancement. In addition, I have engaged in the development of regulations for bird safety in several Santa Clara Valley cities, including: a 2021 ordinance in the City of Cupertino, the San Jose Downtown Design Standards and Guidelines (2019), and the Citywide Design Standards and Guidelines (2021).

I am also a member of the National Audubon Society Bird-Friendly Communities effort and the American Bird Conservancy Collision Network.

Method

In preparation for this review, I reviewed the following documents, available on the City's Almaden Office Project website:

- First Amendment to the SEIR and First Amendment attachments,
- Almaden Office 1st Draft SEIR Public Comments,
- Supplemental EIR,
- Appendix A: Initial Study,
- Appendix C: Arborist Report,
- Appendix D: Biological Resources Report,
- Supplemental EIR 1st draft Public Comment letters regarding riparian corridors:
  - Comment Letter A (California Native Plant Society),
  - Comment Letter E (Guadalupe-Coyote Resource Conservation District),
  - Comment Letter F (Guadalupe River Park Conservancy),
  - Comment Letter G (Jean Dresden),
  - Comment Letter J (San Francisco Bay Regional Water Quality Control Board),
  - Comment Letter K (Sierra Club),
  - Comment Letter L (Valley Water),
  - Please note that I wrote Comment Letter H (Santa Clara Valley Audubon Society), see in the Supplemental EIR 1st draft Public Comment letters.

I also reviewed the City of San Jose Downtown Design Standards and Guidelines (2019), and Citywide Design Standards and Guidelines (2021), available on the City's website.

I reviewed the San Jose Riparian Corridor Policy Study (1999). This document provides a strong foundation for requiring 100-ft setback from the riparian edge of San Jose streams.

I reviewed eBird, a bird observation database managed by the Cornell Lab of Ornithology. It is the primary online, citizen science, scientifically vetted online database for birds. eBird data documents bird distribution, abundance, habitat use, and trends through data collected by birders who submit checklists showing when, where, and how they went birding, and then fill out a checklist of all the birds seen and heard during the outing. I also reviewed iNaturalist data. iNaturalist is one of the world's most popular citizen science tools. It is a joint initiative of the California Academy of Sciences and National Geographic.

I used Calscape, a California Native Plant Society database, for some of the information regarding native trees.

I have also conducted several site visits (March 18, 2019; September 9, 2019; June 26, 2021; and August 29, 2021) to the project site and within the 100-ft setback of the riparian corridor (as defined by the city, the riparian corridor is measured from top of the bank or the dripline of the riparian trees, whichever is greater) to evaluate the quality of the riparian habitat adjacent to the site, and consulted with Mr. Matthew Dodder, Executive Director for Santa Clara Valley Audubon Society and a professional birder[1]

[1] Matthew Dodder has been an avid birder since 1977, and has observed 2000 species worldwide and over 500 bird species detected in California. In Santa Clara County, Mr. Dodder has identified 342 species (~95% of the total number of species recorded in the county). Mr. Dodder has been a Birding instructor at Palo Alto Adult School since 1999-2020 (21 years). He has taught hundreds of students who moved from beginner to advanced and finally

(Mr. Dodder visited the site on August 30, 2021). I reviewed the habitat value of native trees (SK Attachment 1) with Dr. Linda Ruthruff, Conservation Chair for the California Native Plant Society Santa Clara Valley Chapter (Personal communication, August 30 and September 1, 2021) and used references including resources (published and unpublished) from local native plant and pollinator habitat expert Mr. Jeffrey Caldwell[2].

Analysis and Comments

In my opinion, the SEIR's analysis underestimates the high biological value of the riparian area along the Guadalupe river in the area between Woz Way and San Carlos street, especially for birds. In addition, the SEIR does not provide adequate, feasible mitigation for bird collision - mitigations that are required for other developments in the downtown area.

Rivers and their riparian corridors are the most natural and geographical features in urban landscapes. Riparian corridors provide critically important habitat for aquatic invertebrates, fish, amphibians, birds, and mammals, especially in landscapes modified by humans, where the rivers, creeks and their riparian ecosystems are often the last remaining habitats that provide resources and sustain wildlife. Numerous species are dependent on riparian corridors (and water within) for survival at least for some part of their life cycle: foraging, breeding, migration, and dispersal. Many breeding birds in Santa Clara Valley are associated with the riparian corridors, as evident from breeding maps of bird species provided in the Breeding Bird Atlas of Santa Clara County, California[3]. Many of these species nest in riparian corridors that are not pristine.

The Biological Report recognizes that daytime shading of the riparian corridor by tall buildings may over time affect the health and growth of adjacent riparian plants. The SEIR also acknowledges that construction and operations of the project will reduce the use of the riparian corridor by birds and other wildlife species. Despite the predicted degradation of the riparian trees and the reduced usability of the riparian corridor, the report considers the adjacent stretch of the river and its riparian corridor to be of Moderate Value and concludes that the proposed project would not result in a project-level impact since the existing riparian habitat immediately adjacent to the site is of moderate quality (as opposed to high quality). I disagree with this assessment, and with the conclusion. Instead, I find that while not pristine, the riparian habitat in this location and at this setting is of high value for birds and other biota, and significant, project specific impacts are inevitable.

1) **The report fails to recognize the critical importance of the site as a high value natural habitat patch in an urban river continuum where upstream and downstream reaches have been compromised.**

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master birders in that time. He has led hundreds of field trips to all areas of California. Mr. Dodder continues to offer popular birding classes online and has produced dozens of videos for Audubon dealing with bird identification. Mr. Dodder is currently the Executive Director of Santa Clara Valley Audubon Society.

[2] Jeffrey Caldwell is a biologist and horticulturist in Santa Clara County. He is a former chief horticulturist for Theodore Payne Foundation for Wild Flowers and Native Plants.

[3] Breeding Bird Atlas of Santa Clara County, California. (2007). William G. Bousman. Santa Clara Valley Audubon Society.

The conservation value of even small, isolated remnants of habitat have been shown to be much more important for biodiversity conservation than often recognized[4]. This is particularly true in heavily modified, human-dominated landscapes such as cities.
In their global analysis encompassing 28 countries, Wintle et al.[5] show that many species would be lost if small, isolated patches of remnant habitat were ignored and conservation efforts were focused solely on large, intact, and highly connected areas. The work of Wintle et al. adds to the array of case studies that likewise highlight the importance of small (and often relatively isolated) patches for conservation (for example, Leroux et. al. 2007).[6]

The Guadalupe River Corridor in downtown San Jose comprises a series of habitat patches in a linear continuum of concrete channels, underpasses and tunnels, modified creek channels and some unmodified stretches. Some of the modified creek channels retain moderate habitat quality where riparian trees and vegetation are present, but the highest habitat value in an urban setting such as downtown San Jose is its riparian corridors and in these corridors, unmodified stretches with diverse community of riparian trees have the highest value, especially in areas where adjacent parks provide buffers and healthy riparian forest shades the river and provide habitat for fish, birds, and other wildlife.

2) **The report underestimates the habitat value of the riparian forest, and the diversity and abundance of bird species in the riparian corridor and its vicinity. As a result, it mistakenly finds that existing riparian habitat adjacent to the project site is of only moderate quality.**

eBird identifies the area delineated by San Carlos Street, Almaden Blvd., and Woz Way , including the Guadalupe River Trail and Discovery Meadows park, as a birding hotspot. The attached eBird "profile" of this area (SK Attachment 3 and https://ebird.org/hotspot/L1316518). 98 checklists have been submitted for this location since May, 2004. A total of 95 species have been recorded there. Of the **95 avian species** known to utilize this area, several are migratory species associated with riparian habitats (especially in urban areas)[7]. These riparian species are: Pacific-slope Flycatcher, Tree Swallow, Hooded Oriole, Bullock's Oriole, Orange-crowned Warbler, Yellow Warbler, Yellow-rumped Warbler, Townsend's Warbler, Wilson's Warbler and Western Tanager.
In addition, it is important to note the variety of avian families represented at this hotspot. 5 species of Woodpeckers, 4 species of Hawks, 2 species of Falcons, 4 species of Flycatchers, 2 species of Vireos, 3 species of Thrushes, 5 species of Swallows, 5 species of Finches and 8 species of Sparrows. These families include species that feed in trees, grasslands, and the air. It

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4 https://www.pnas.org/content/116/3/717

5 Wintle BA, et al. (2019) Global synthesis of conservation studies reveals the importance of small habitat patches for biodiversity. *Proc Natl Acad Sci USA* 116:909–914.Abstract/FREE Full TextGoogle Scholar (SK Attachment 2)
Bennet, et al. (2014) Riparian vegetation has disproportionate benefits for landscape-scale conservation of woodland birds in highly modified environments. *Journal of Applied Ecology* (SK Attachment 4).
Tulloch, et al. (2016) Understanding the importance of small patches of habitat for conservation. *Journal of Applied Ecology* (SK Attachment 6).
Lindenmayer. (2019) Small patches make critical contributions to conservation efforts. *Proc Natl Acad Sci USA* (SK Attachment 5).

6 Leroux SJ, et al. (2007) Minimum dynamic reserves: A framework for determining reserve size in ecosystems structured by large disturbances. *Biological Conservation*.

7 Mr. Matthew Dodder, Personal communications.

includes species that feed on seeds, fruit, insects and other animals. This is testament of the value of this location.

Mr. Dodder visited this section of the riparian corridor on Monday, August 30, 2021. He reported 11 species including Western tanager (a migratory species) found in the riparian cottonwoods, 5 individuals of Western bluebird in the park (3 young being fed by 2 adults), and several individuals of Chestnut-backed chickadees along the creek and near trees.

Mr. Dodder observed:

> "I was impressed with the variety of riparian vegetation in the area. Sycamore and willows are especially productive for birds as they set up nests or pause in the area to feed. There were also a variety of oaks and a number of ornamental trees. The banks of the creek were festooned with low growth that could host smaller, secretive breeding species. The water way was blocked in places, but small pools could serve as resting and refueling stops for migrant species.
>
> I fully expect that both Bullock's Oriole and Hooded Oriole will be found here in spring as the willow and sycamore habitat is perfect, as are the nearby fan palm trees. Both have been found by other birders.
>
> The habitat is also perfect for Song Sparrow, but loud nearby construction prevented me from detecting the species. It has been detected by other visitors and was recorded on their checklists."

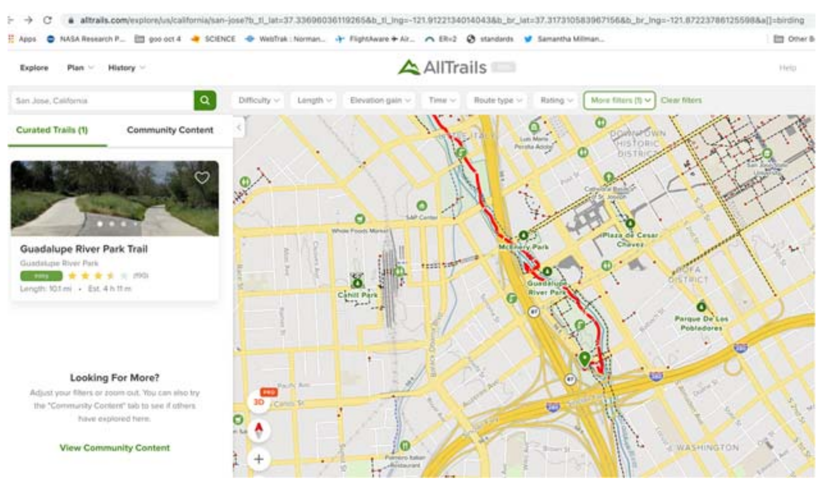
Mr. Dodder's visual bird observations from August 30, 2021 can also be found at this eBird checklist: https://ebird.org/checklist/S93957075.

The diversity of avian families and species is likely supported primarily by the diverse riparian forest in the creek. The SEIR and associated documents, and site visits I conducted onsite demonstrate a healthy and robust riparian forest in a relatively wide riparian stretch along the river. The riparian forest comprises a diverse and mature community of California native trees, non-native trees and dense understory vegetation. As reported by the Biological resources report (and supported by my observations), the riparian canopy includes native coast live oaks (Quercus agrifolia), red willows (Salix laevigata), and Fremont cottonwoods (Populus fremontii), with lesser numbers of native valley oaks (Quercus lobata), box elders (Acer negundo), California bays (Umbellularia californica), western sycamores (Platanus racemosa), and California buckeyes (Aesculus californica), as well as non-native trees. While non-native trees and vegetation provide limited food sources for birds, when mixed with native trees of high habitat value such as the native trees onsite, the riparian forest can have a high habitat value, especially in an urban setting. The importance of a water source - the Guadalupe river - is also critical to resident and migratory birds, especially as cities and water agencies mandate water savings and surface water is becoming scarce in the urban landscape.

The native trees onsite have the potential to support dozens of species of invertebrates (SK Attachment 1, compiled with the help of Dr. Linda Ruthruff) and provide food for insectivorous birds, fish, and other wildlife species. A search of the iNaturalist database for the riparian

corridor shows, among other observations, 2 amphibians species, 2 reptiles, 14 moth/butterfly species as well as other insects, arachnids and more.
These observations include the arboreal salamander (amphibian), California slender salamander (amphibian), Western fence lizard (reptile), turtle (reptile), and the following moths/butterflies: painted lady, gray hair streak, common checkered-skipper, Western tiger swallowtail, polyphemus moth, Western monarch butterfly, red admiral, gulf fritillary, fiery skipper, anise swallowtail, mourning cloak, Western tussock moth, garden tortrix, and cabbage looper moth[8]. This abundance of prey species helps explain the diversity of birds in the riparian corridor, and supports my conclusion that this riparian patch is of high habitat quality. Please note that the Western monarch is now a candidate under the Endangered Species Act [9].

The value of the site for birds is further substantiated by the fact that a Google search for "Best bird watching trails in San Jose, California"[10] shows the Guadalupe River Park Trail across the river from the project site as one of the most popular, accessible sites for watching birds.



The impacts to birds at the site will degrade an important birding recreation site for San Jose residents and visitors.

8 iNaturalist
9 https://www.fws.gov/savethemonarch/SSA.html
10 AllTrails maps and bird watching trails, https://www.alltrails.com/us/california/san-jose/birding

3) The Biological Resources Report and SEIR wrongly argue that the riparian habitat adjacent to the project site is of moderate habitat value and concludes that the proposed project would not result in a project-level impact since the existing riparian habitat immediately adjacent to the site is of moderate quality (as opposed to high quality).

The Biological Studies Report provides (page 7), "Shading of the riparian habitat by the buildings will reduce the amount of light received by riparian trees and plants, potentially affecting the health and growth of these plants". In response to comment from Jean Dresden (p. 37) the First amendment provides "...the proposed towers would shade the adjacent habitat throughout some of the morning hours year-round". The Biological Resources Report establishes an expectation that "some degradation of the riparian habitat over time as a result", but finds no significant impacts "since the existing riparian habitat immediately adjacent to the site is of moderate quality"

During a site visit (August 29, 2021), I roughly estimated the proportion of native trees and canopy onsite to be over 70% of the riparian canopy. The foreseeable degradation of the tree canopy due to shading by the proposed building, cannot be taken lightly. The reduction of available sunlight can modify the tree composition and reduce the proportion of native trees with preference to full-sun conditions, such as valley oak, Fremont cottonwood, and Western sycamore[11]. The degradation of the riparian forest due to shading and potential change in tree composition can reduce the availability of food resources such as acorns or insects in the tree canopy and in tree trunks. This will compound the significant, unavoidable reduction of the riparian habitat value of the river adjacent to the project site.

3.1) The riparian corridor includes a large number of non-native trees and understory, and disturbance from homeless activity (SEIR Appendix D Biological Resources Report at page 5)

> As I have shown, the site is a birding hotspot that provides habitat to migratory birds and a wide spectrum of avian taxa. The data establish that the riparian corridor and its environment are of high quality for birds (SK Attachment 3).

3.2) "The habitat is not likely to be heavily used by migrating birds." The biologist conducted a one-hour site visit September 7, 2018 and observed 45 individuals of 13 bird species. The biologist states, "all species were relatively common native birds that are widespread in the region and only one was dependent on riparian systems (mallard). None of these were migrants, even though timing of visit just prior to peak migration of Neotropical migrants in the area)." (SEIR Appendix D Biological Resources Report at page 5).

> The data from eBird and observations by Mr. Dodder and others show that a diverse community of birds, including migratory birds, use the habitat

3.3) Habitat fragmentation due to surrounding high-density urban development and presences of bridges, road crossings, and channelization along nearby portions of river, and therefore the "site lacks

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[11] https://calscape.org/

connectivity to higher-quality riparian habitats in the region" (SEIR Appendix D Biological Resources Report page 5).

> Based on scientific evidence of the importance of small habitat value, Mr. Dodder's observations and my own experience, I believe that this "patch" of habitat is critically important to birds and wildlife connectivity along the Guadalupe River exactly because it is located in a developed urban landscape, and allows birds and other species to find refuge, forage, rest, roost and breed along the river. As stated above, the riparian corridor supports a mature and diverse native tree canopy that provides high quality habitat. In this area, this high quality habitat serves as an important stepping stone along the fragmented riparian corridor of the river (SK Attachments 2, 4, 5, 6).

Conclusion

On page 7, the Biologist Resources Report states, "In our opinion, based on the moderate quality of the riparian habitat present and the native bird community present at this location, coupled with the ecological value of the Guadalupe River on the scale of the Santa Clara Valley, a 100-ft standard setback is appropriate between new building construction and the Guadalupe River on the project site to maintain suitable riparian functions and values. For the purposes of this project, the standard 100-ft setback extends landward from the outer edge of the riparian habitat along the Guadalupe River…". I concur.

I believe that due to the foreseeable degradation of the riparian canopy due to shading, and the intrusion into the riparian corridor, this project has the potential to result in substantial degradation of riparian bird communities in the segment of the Guadalupe River adjacent to the project site and beyond. The encroachment impact on riparian birds and habitat, in my opinion, is a significant impact under CEQA on a project-specific basis as well as a cumulative basis.

4) The SEIR's analysis of bird collision impacts is incomplete and inaccurate.

4.1) Impact Bio-1 erroneously does not identify the building's eastern façade as hazardous to birds. Mitigation Measure Bio-1 should apply to all 4 facades of the building.

For over 4 years, I have been a participant in online discussion forums and monthly calls organized by the National Audubon Society and by the American Bird Conservancy (ABC). Both forums provide presentations and discussions focusing on bird collision monitoring efforts, location-related hazards, building architecture (including overall architecture, specific features, height, elements that increase collisions, lighting, the effectiveness of mitigation measures and more). Several of the participants in these forums are from the west coast, and a few from California. The discussions show surprisingly consistent location and architectural hazards across the continent. In locations adjacent to riparian and other sensitive habitats, bird collisions are common at all facades and all heights. Of special concern here, buildings that are curvilinear or include indentations, these features trap birds in situations where veering from a flight path is difficult to perform in mid-flight. Raptors such as hawks and falcons are known to collide with buildings when they chase birds in flight. With 6 species of hawks and falcons in the riparian corridor, this is of great concern.

In monitoring bird collisions in Mountain View and Sunnyvale (on behalf of Cushman and Wakefield), I observed glazed facades that were prone to bird collisions even when they were oriented away from creeks or open space, but within 300-ft of such habitats.. These observations hold true even where there is little vegetation near the facades. Observations by over a dozen contributors to the Audubon and the ABC networks support the need for implementation of bird safety measures , at a minimum, within 300-ft of creeks and other habitat areas.

San Jose implements requirements for bird safety near the Bay (with some added protection in creek corridors citywide; Riparian Corridor Protection and Bird Safe Design Council Policy 6-34, 2016), within 300 feet of a creek or a river Citywide (Section 3.3.6 Bird Safety in the Citywide Design Standards and Guidelines, 2021) and downtown (section 4.4.2.b Bird Safety Downtown Design Guidelines ("DTDG") and Standards, 2019). Recent projects in the downtown area have been required to abide by the DTDG (Woz Way) and some projects voluntarily exceed these requirements (Downtown West).

The importance of the riparian corridors to birds are also the reason why San Jose's DTDG requires bird safety application to all facades of buildings that are located within 300 feet of a riparian corridor, regardless of the exact location of the building, and whether or not a facade is visible from the riparian corridor. This is a feasible mitigation that should apply to the project as it does to all other developments.

Mitigation Measure BIO-1.1 recognizes the potential for the proposed towers on the project site to result in a high number of bird collisions. SEIR Mitigation Measure MM BIO-1.1 at pages 51 and 52. However, the mitigation measure would only apply to the building's north, west, and south-facing façades. *Id*. The SEIR does not provide any justification for excluding other portions of the building from mitigation. All glass facades of the project, including the podium, are within 300 feet of the riparian corridor, and therefore, have the potential to result in a high number of bird collisions, and the mitigation should also apply to the podium and the east facade. San Jose DTDG at page 49.

In addition, Council Policy 6-34 section 4 provides:

> "4) <u>Materials and Lighting</u> a. New development should use materials and lighting that are designed and constructed to reduce light and glare impacts to Riparian Corridors. For example, the use of bright colors, and glossy, reflective, see through or glare producing Building and material finishes is discouraged on Buildings and Structures".

The proposed building is composed entirely of glazed facades. The renderings show a see-through design, which is (in my experience) greatly hazardous to avian species even when bird safety treatments are applied to the glazing. Furthermore, it can be expected that in the afternoons, sun will hit the building, and light will be reflected, introducing glare into the riparian corridor and reducing habitat value for birds.

1. <u>The Project's Impact of Bird Collisions is Significant Even With Proposed Mitigation</u>

Based on my experience and resources, I believe that the riparian habitat nestled between the project and the Discovery meadow area is of high quality, and that the proximity of the building to the Guadalupe River, the height of the building and its long curvature along the river pose an unmitigable impact to birds, especially migratory birds that fly at night.

As migratory birds travel along riparian corridors, tall buildings in proximity to quality habitat areas can cause substantial increase in bird collisions as migratory birds ascend from or descend to forage, roost, or breed. The importance of the 300-ft buffer is recognized by many cities in their planning efforts, including the City of San Jose in its Design Guidelines and standards.

To protect birds migrating to and along the riparian corridor, the City of Santa Clara's Tasman East Specific Plan[12] restricted building height within 300-ft of the top of bank of the Guadalupe River and nearby natural habitat to 55-ft. The City of Mountain View's North Bayshore Precise Plan[13] restricts any new development near creeks mandating a 150-ft buffer (Habitat Overlay Zone) even for creeks in an urban setting that have no riparian forest, such as the channelized Permanente Creek. The plan further reduces building height near sensitive areas by restricting building heights to 55-ft within 100 feet from the boundary of the Habitat Overlay Zone, (for creeks - 250-ft altogether) to provide an additional buffer between sensitive resources and taller buildings. The Downtown West (Google) project in downtown San Jose reduces the volume and massing of buildings within 150-ft of the riparian corridor of Los Gatos Creek

In addition to the restriction of building heights near riparian corridors, the City of Santa Clara requires bird safety treatment applications for the buildings that are within 300-ft of the river. In Mountain View, all new buildings in North Bayshore, and most new buildings in the City are required to implement bird safety measures (some exemptions may be considered, but not at the scale of the proposed project or near waterways).

The City of Santa Clara, even with a wider setback from the Guadalupe River than the narrow setback this project proposes, and height restriction and the requirement of bird safety glazing, has found the impact of bird collision to be significant and unavoidable.

The City of Cupertino considers areas within 300 feet of the Wildland Urban Interface; within 300 feet of watercourses to be "Bird-Sensitive Areas". In these areas, for all new development, no more than 10% of the surface area of the façade can be untreated glass between the ground and 60 feet above ground. No more than 5% of the surface area of the façade may be untreated glass between 60 feet above ground and up.

The enormity in height and length of the Project, its curvature and its siting within 300 feet of the riparian corridor are in my opinion, a significant unavoidable project-specific impact to birds. Furthermore, other glass tower developments are planned along the Guadalupe River in the San Jose downtown area (Woz Way, Adobe tower, Downtown West and more). All these developments would construct massive glass buildings within 300 feet of the river. Even with mitigation measures, the cumulative impacts of bird collision would be significant.

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Santa Clara Valley Audubon Society

[12] https://www.santaclaraca.gov/Home/Components/BusinessDirectory/BusinessDirectory/152/3649
[13] https://www.mountainview.gov/civicax/filebank/blobdload.aspx?BlobID=29702

1414108.1

ATTACHMENT 1

Almaden Office Park
Habitat Values of Riparian Corridor Native Trees
Trees are from the H.T. Harvey Biological Resources Report

(Native) Oaks may be the most valuable plant for wildlife in California. . .

All parts of the oak. . . are food sources for insects, birds and mammals. Oaks attract many insects which feed many bird species, reptiles, and amphibians. . . and offer nesting sites and cover (Bauer p. 179.)

Mature trees can produce 500 lbs. of acorns (Bornstein.)

1. **Coast Live Oak** (***Quercus agrifolia.)***

Butterflies: Host plant: California Sister; Propertius Duskywing; Mournful Duskywing; several hairstreaks; Great Purple Hairstreak on mistletoe that grows on Oaks (Shapiro.)
Sap: Mourning Cloak
Moths: Records found for 50 + moths (Caldwell 1.)
Bees: Habropoda females use pollen (Frankie.) Records for Honey bees + 2 others (Caldwell 2.)
Birds: Many species feed attracted insects to nestlings; adults feed on insects, amphibians and acorns. Nesting sites and cover (Bauer.)

2. **Valley Oak** ***(Quercus lobata.)***

These impressive elegant trees are survivors. They have faced droughts, fires, diseases, and pests, yet they persist, some reaching 400 to 600 years of age (Bornstein . 162.)

Butterflies: Host plant: California Hairstreak; Propertius Duskywing; Mournful Duskywing; Great Purple Hairstreak on mistletoe that grows on Oaks (Shapiro.) Gold-hunter's Hairstreak (Caldwell 1.)
Moths: Records for 30 + moths (Caldwell 1.)
Bees: Habropoda females use pollen (Frankie.) Nectar: Honeybees (Caldwell 2.)
Birds: Many species feed attracted insects to nestlings; adults feed on insects, amphibians and acorns. Nesting sites and cover (Baeur.)

3. **Red Willow** (***Salix laevigata.)***
(Many willow records are not specific to the species level (Caldwell 1.)

Butterflies: Host plant: Mourning Cloak; Lorquin's Admiral; Western Tiger Swallowtail; Sylvan Hairstreak (Shapiro.)
Sap: from sapsucker wounds draws Lorquin's Admiral, Red Admiral, Milbert's Tortoiseshell, Mourning Cloak, Common Wood-Nymph, Hoary Comma, Green Comma, Satyr Comma, and other sap feeders, especially moths.
Nectar: records for 16 + (Caldwell 1.)
Moths: Records for 80 + moths associated with willows (Caldwell 1.)
Bees: Early flowers an important nectar source for bees (Bauer.)

4. <u>Western Sycamore</u> (Platanus racemose.)

Butterflies: Host: Western Tiger Swallowtail; Two-tailed Swallowtail: Also hosts Mistletoe which is host for Great Purple Hairstreak (Shapiro.)
Moths: Host for three moths (Caldwell 1.)
Birds: Seeds: Goldfinches and other birds. Nectar for Hummingbirds. Nesting and roosting for many songbirds (Caldwell 3.) Provides cover for birds and others (Bauer.)

5. <u>Fremont Cottonwoods</u> (Populus fremontii.)

Butterflies: Host: Western Tiger Swallowtail; Mourning Cloak; Lorquin's Admiral; and Dreamy Duskywing (Caldwell 1.) Also hosts mistletoe which is a host plant for Great Purple Hairstreak (Shapiro.) Attracts many butterflies (Sunset.)
Moths: Host plant for 20 moths (Caldwell 1.)
Bees: Dead trunk areas are popular long-term nesting sites for Carpenter bees (Frankie.)
Birds: Provides cover for birds and others (Bauer.) Especially attractive to hawks, eagles and woodpeckers. Many other birds forage and nest (Caldwell 3.)

6. <u>California Buckeye</u> (Aesulus altissima.)

Butterflies: Host: Second generation of Echo Blue; Echo Azure
Nectar: Blooms for April to June, extremely important nectar source for almost all adult butterflies during that time period including: Pipevine Swallowtail, Western Tiger Swallowtail, Pale Swallowtail, Gorgon Copper, Golden Hairstreak, Crown Fritillary, and many others (Shapiro.)
Moths: Host plant for 7 moths. Nectar plant for 7 moths (Caldwell 1.)
Birds: Very attractive to Hummingbirds (Bauer.) Attracts many insects which birds feed their young and feed insect eating adults (Caldwell 3.)

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ATTACHMENT 2

Global synthesis of conservation studies reveals the importance of small habitat patches for biodiversity

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Island biogeography theory posits that species richness increases with island size and decreases with isolation. This logic underpins much conservation policy and regulation, with preference given to conserving large, highly connected areas, and relative ambivalence shown toward protecting small, isolated habitat patches. We undertook a global synthesis of the relationship between the conservation value of habitat patches and their size and isolation, based on 31 systematic conservation planning studies across four continents. We found that small, isolated patches are inordinately important for biodiversity conservation. Our results provide a powerful argument for redressing the neglect of small, isolated habitat patches, for urgently prioritizing their restoration, and for avoiding simplistic application of island biogeography theory in conservation decisions.

Zonation | fragmentation | complementarity | irreplaceability | prioritization

Island biogeography and subordinate theories from metapopulation ecology and landscape ecology indicate that species richness and individual species' population sizes in a habitat patch will depend on the degree of isolation of the patch (e.g., distance to nearest neighbor or mainland), the size of the patch, and the quality of the habitat contained within the patch (1). Theory underpinning metapopulation ecology also emphasizes the role of size in enhancing populations' robustness to stochastic perturbations, and the role of connectivity in increasing gene flow and the probability of rescue following local extinctions (2, 3). Many studies in landscape ecology focus on the role of large patches in avoiding negative edge effects arising from fragmentation (4, 5). Each of these drivers point to the importance of large, connected patches of habitat for ensuring the persistence of species and conserving species richness, and to the lower ecological value of landscapes comprising many small, isolated patches with extensive edge environments.

Conservation planning principles of representativeness and complementarity have been introduced into conservation practice (6) to provide a pragmatic basis for conserving biodiversity in rapidly changing, fragmented landscapes under pressure from threats such as land clearing or climate change. These principles are embodied in conservation decision support tools (7, 8) that can be used to identify areas that most cost efficiently ensure the representation of at least some part of each species range in protected areas. Operationally, areas are identified for protection so as to complement existing conservation efforts. This approach has been applied to many conservation decision problems, such as rezoning marine parks in California and wilderness areas in Indonesia (9), assessment of large scale urban expansion in Western Australia (10), evaluation of the coverage and comprehensiveness of the Natura 2000 network (11), and expansion of Madagascar's protected area network (12).

The predisposition toward larger and more connected areas has found its way into conservation and land use policy in many jurisdictions, sometimes in perverse or undesirable ways. In many jurisdictions, such as Australia, Canada, Brazil, and New Zealand, small patches of habitat may be cleared without significant regulatory impediment or requirements for compensation such as biodiversity offsetting (13). It is common to see strong conservation policy emphasis on the protection or enhancement of large, mostly intact landscapes (14) and avoidance of areas containing many small fragments (15). Most of these policies and approaches to setting conservation priorities are implemented without any particular consideration of the level of threat currently faced in those landscapes, or the degree to which conservation of the areas in question would complement existing conservation reserves and improve representation of species habitats that are currently poorly represented in conservation reserves (14).

Arguably, a greater emphasis on representativeness and complementarity has emerged in places where the influence of technical experts in conservation planning is greatest. This is the case in Australia, which has seen government policies that seek to create a "comprehensive, adequate and representative" reserve system (16). Nonetheless, in Australia, vegetation management and conservation policy continue to prioritize larger and more connected areas over smaller, more isolated fragments, and downplaying their value in offsets and vegetation loss regulations and policies. For example,

Significance

Expansive development for urbanization, agriculture, and resource extraction has resulted in much of the Earth's vegetation existing as fragmented, isolated patches. Conservation planning typically deprioritizes small, isolated patches, as they are assumed to be of relatively little ecological value, instead focusing attention on conserving large, highly connected areas. Yet, our global analysis shows that, if we gave up on small patches of vegetation, we would stand to lose many species that are confined to those environments, and biodiversity would decline as a result. We should rethink the way we prioritize conservation to recognize the critical role that small, isolated patches play in conserving the world's biodiversity. Restoring and reconnecting small isolated vegetation patches should be an immediate conservation priority.

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Data deposition: All R code and raw data inputs (i.e., Zonation outputs and environmental layers) used in analyses are available at https://figshare.com/s/29477d872ea6ca2f9962.

See Commentary on page 717.

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offsetting requirements are more stringent for larger patches in Victoria and New South Wales (17, 18). Globally, the "bigger (and more connected) is better" logic continues to dominate conservation policy, and the scientific community appears largely to reinforce this view (2, 19), but not without dissent (15). The current focus of conservation scientists on conserving large intact landscapes may have the unintended consequence of downplaying the importance of small, isolated, remnant patches of habitat in fragmented landscapes in the eyes of policy makers, land planners, and conservation organizations (13).

There are pragmatic arguments against the default policy of focusing conservation effort predominantly or solely in large and connected patches of habitat. In human dominated landscapes where past urban and agricultural development has favored flat, fertile environments, the remaining small and isolated patches of vegetation tend to host species and ecological communities notably different than those occurring on poor soils or steep locations where the majority of existing conservation areas are placed (20). The size of remnant patches of habitat is not the only consideration. The more isolated remnant patches are from large intact patches, the more likely they are to be different in species composition, based on the characteristic spatial autocorrelation observed in most environmental data (21). Finally, small and isolated patches, such as those in more urbanized environments, tend to be disproportionately susceptible to processes such as weed and feral pest invasion or illegal clearing. Without protection and restoration, opportunities to incorporate these patches with unique species composition into a reserve system may disappear quickly, making immediate protective action necessary. Hence, the case for securing, protecting and restoring small patches may be more urgent, as they tend to be more threatened by clearing or degradation than larger patches.

Herein lies an important conceptual, practical, and sociological challenge for conservation practitioners: Should we focus conservation efforts on protecting large, less vulnerable patches of habitat that may contain species relatively well represented in existing conservation areas? Or should we focus efforts on preserving and restoring the often more degraded, but possibly more ecologically unique, small and isolated patches of habitat that could contain species less well represented in existing conservation areas?

While this question requires both practical (cost, logistics) and sociological (preferences for large wild areas versus protection of rare species habitats) considerations, we approach this problem from an ecological perspective by testing the hypothesis that small and isolated patches of remnant habitats in fragmented landscapes tend to contain unique biodiversity that is not well represented in large, contiguous conservation reserves. This is an important issue to resolve, because it determines how much effort conservation scientists should invest in moving the focus of policy makers toward conserving and restoring small and isolated patches of vegetation that are often quite degraded and threatened by many stressors, and potentially more costly to manage per unit area.

While a number of authors have explored the relationship between patch size, isolation, and species richness in fragmented landscapes, with mixed findings (2, 15, 22 30) (*SI Appendix*, section S1), we could find no studies that explicitly quantify the relationship between patch size, isolation, shape, and conservation value based on the principles of complementarity and representativeness.

We utilize a global synthesis of 31 spatial conservation studies, implemented using the spatial prioritization software Zonation (7), in 27 countries across four continents. We statistically synthesize the results of these studies by quantifying the relationship between conservation value and the size, shape, and isolation of habitat patches in each study landscape. Our synthesis allows us to draw significant empirical generalities about this relationship and provide evidence based advice on the importance of small habitat patches for conservation.

Results and Discussion

Our central result indicates a working hypothesis for land managers and policy makers: that small, relatively isolated habitat patches of high shape complexity in fragmented landscapes tend to be of higher conservation value according to a complementarity and representativeness criterion than a similar sized habitat patch within contiguous tracts of intact vegetation of low shape complexity. The key finding of our analysis is that patch size, proportion of intact vegetation in a 5 km radius, and fractal dimension index had a statistically significant effect ($P < 0.01$) on conservation value across the 31 conservation prioritization case studies in our global data set. Our final fitted model indicates that conservation value tends to decrease as patch size increases and the intactness of the surrounding landscape increases. Conservation value also increases with increasing fractal dimension (a measure of patch shape complexity), but tends to decrease with increasing perimeter–area ratio (Fig. 1). A final model including an autocovariate term and cubic transformations of 4 of the 16 candidate patch variables provided the most parsimonious and interpretable explanation of spatial variation in Zonation conservation rank (a measure of conservation value and the dependent variable in our analysis). All variables and interactions in the final model were statistically significant ($P < 0.01$).

To help interpret the size of the effect we are reporting, our result indicates that a land unit of around 1 ha selected at random from a small patch of habitat (<1,000 ha) with a complex shape that is predominantly surrounded by cleared or degraded area (e.g., <20% area in a 5 km radius under natural vegetation) will tend to have a substantially higher conservation value than a similar unit selected from a large habitat patch within a largely intact landscape. However, patches characterized by high perimeter–area ratio (often linear patches of habitat along road and river edges in cleared landscapes) tend to have lower conservation value, holding all other variables at their mean. In our case study regions, we would expect the conservation value to reduce by a factor of ∼3 with a doubling of the proportion of habitat in a 5 km radius or a doubling patch area, holding all other variables at their mean (Fig. 1 and *SI Appendix*, section S2).

Looking at species distribution maps (31) for rare or highly restricted species and comparing them to conservation priority maps in some of our case study regions allows us to further tease out the reasons for the statistical relationships observed across the multiple spatial prioritizations we examined. For example, the Perth Peel region of southern Western Australia is highly representative of the more fertile and wet coastal regions of the Australian continent (Fig. 2). The region is characterized by a few large contiguous tracts of forest at a relatively large distance from urban and coastal areas, and many much smaller fragments of habitat embedded in a matrix of agriculture and urban development closer to the coast. For the bulk of species found in the larger, contiguous forest areas, loss of any particular hectare of that environment would generate a relatively small overall proportional loss in available habitat. Conversely, closer to the coast, the loss of any small patch of vegetation leads to a significant (and in some instances total) loss of suitable habitat for species confined to those patches, and hence those small patches are afforded a very high conservation value in a regional Zonation analysis. For example, the Western ringtail possum (*Pseudocheirus occidentalis*) is a Critically Endangered (Environment Protection and Biodiversity Conservation Act 1999) arboreal marsupial that has retracted to the few remaining fragments of the coastal plain of southwest Western Australia (Fig. 2*A*). The fragments of habitat in which it persists tend to be small and isolated; however, a conservation plan for the Perth region must include those patches if it is to ensure representation of the range of this species. Three other species one migratory bird (red necked stint, *Calidris ruficollis*) and two endemic plants (*Dillwynia dillwynioides* and the endangered glossy hammer orchid *Drakaea elastica*) rely on the same small fragments of habitat close to Perth. These

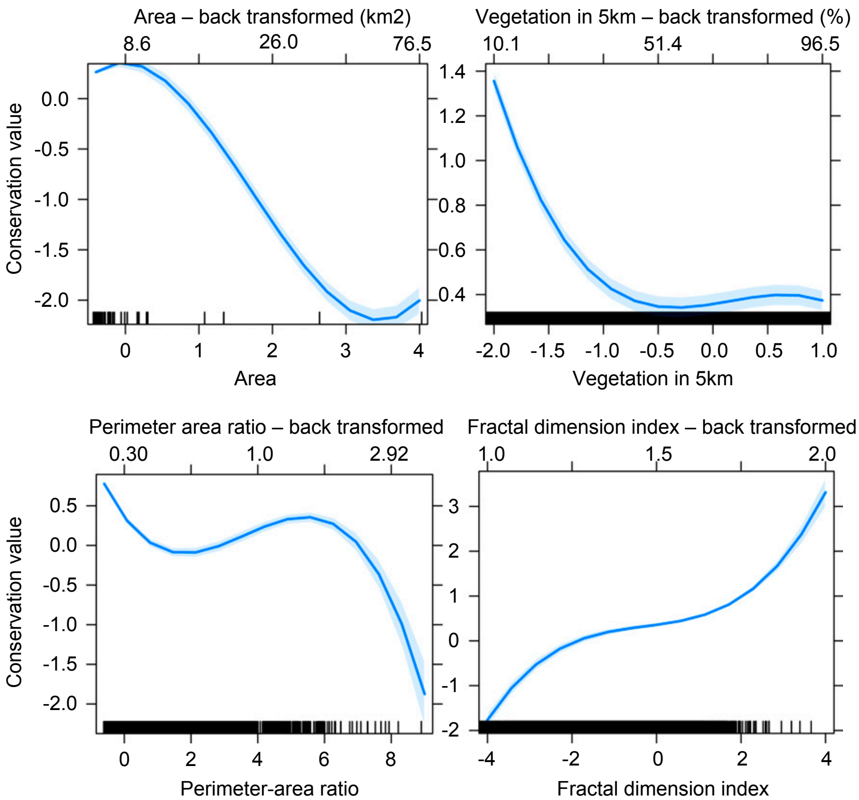

Fig. 1. Relationship between conservation value (logit transformed) and the four patch level independent variables from the global model. Independent variables presented are patch area, proportion of cells containing natural vegetation in a 5 km radius, the fractal dimension of the habitat patch, and the perimeter area ratio of the patch in which the cell is located. The *x* axes along the bottom of the plots give standardized values of independent variables used in the regression. Equivalent raw values are given on the upper *x* axes. The conservation value of a landscape unit (a single raster cell) is defined by its conservation importance rank, as determined by a Zonation analysis (*y* axis), that takes into account the proportion of species' ranges contained within each cell. Cells with a high conservation rank will tend to be ones that constitute a larger proportion of the remaining range of a species. Zonation conservation values that range on the scale [0,1] were logit transformed to allow linear modeling (43). All independent variables were standardized, so the scale on the *x* axes represents SDs from the mean. Each of the relationships depicted here were statistically significant at $P < 0.01$. Each of the independent variables was fitted as a cubic polynomial. An interaction between patch area and fractal dimension was included in the AIC best model (*SI Appendix*, section S2). An autocovariate term was fitted to reduce spatial autocorrelation in model residuals (see *SI Appendix*, section S2 for details).

species are "driving" the prioritization (32) of those small habitat fragments midway down the coast in the Perth region (Fig. 2*A*).

A similar situation can be observed in the Pacific Northwest United States case study (Fig. 2*B*). The large central area of the region around the Willamette River has a very high conservation value rank (Fig. 2*B*, *Left*), despite being an area of high urbanization and agricultural impact. The environmental conditions that made the fertile valley a place to settle, farm, and build cities also make it suitable for a particular set of grassland birds such as the Threatened streaked horned lark (*Eremophilia alpestris strigata*) (Endangered Species Act 1973), and the declining western meadowlark (*Sturnella neglecta*) that have relatively little suitable habitat elsewhere in the region. The fact that much of their habitat is severely altered or destroyed by agriculture and urbanization means that what remains is crucial for preventing these species from going locally extinct and for halting the loss of regional biodiversity. Here, as in the fragmented regions around Perth and the other case studies in our dataset, high conservation value coincides with lower native vegetation extent distributed in smaller patches with complex shapes characteristic of the fragmented parts of those landscapes.

This result provides quantitative evidence and a powerful argument that small remnant patches of habitat should, by default, be highly valued, more than they currently are in many jurisdictions. Indeed, we may be gravely mistaken in deprioritizing small, isolated patches, as their continued loss will almost certainly lead to local, and in some instances global, extinctions. Small intact patches of vegetation in areas otherwise largely cleared of vegetation tend to support the last individuals of species that have been eliminated from other parts of the landscape due to systematic destruction of similar habitat types (33). This study systematically analyzes and statistically quantifies this effect across diverse landscapes globally, reinforcing the need to avoid the continued loss of small isolated patches of habitat, even when concerns exist about the long term viability of species in such patches.

The landscapes analyzed in this study have been cleared or heavily modified for as little as 80 y (Australia), and, in many cases (in Europe), for hundreds of years. For most animal species, even 80 y is enough for extinction debts to play out (34). The same can be said for the bulk of the threatened plants included in these studies, although, for long lived tree species, it may take hundreds of years for extinction debts to be realized. Our results show that large conservation gains could be achieved by protecting, restoring, and increasing the size and connectedness of small remnant patches, where many rare and threatened animals and plants still survive. International agreements such as the Bonn Challenge (35), and associated regional initiatives such as Africa's Great Green Wall (36) and China's Grain for Green project (37), are providing impetus to restore habitats. These are catalyzing ambitious national restoration goals, with a current focus on forests and the numerous ecological and carbon sequestration benefits. There remain significant challenges to introducing biodiversity into such initiatives. Nonetheless, with a growing interest in broad scale restoration for multiple social and environmental benefits, taking more of a restoration perspective to identifying conservation priorities is becoming a very realistic strategy.

Our models explain a small amount of the spatial variation in conservation value across our global data sets. While our main effects were all statistically significant (*SI Appendix*, section S2) and ecologically sensible in the responses they represent, there are clearly other environmental and social processes not included in our models that drive spatial variation in conservation value. Patchiness in species distributions due to competition, disease, and other ecological processes will drive spatial variation in conservation value that cannot be easily mapped and modeled at a global scale. While it was impossible to sample the full range of environments in this study, we have sampled a wide range of geographies, climates, and land use histories. Areas such as The Netherlands, with only 16% of the landscape comprising natural or seminatural vegetation cover, contrast with relatively intact

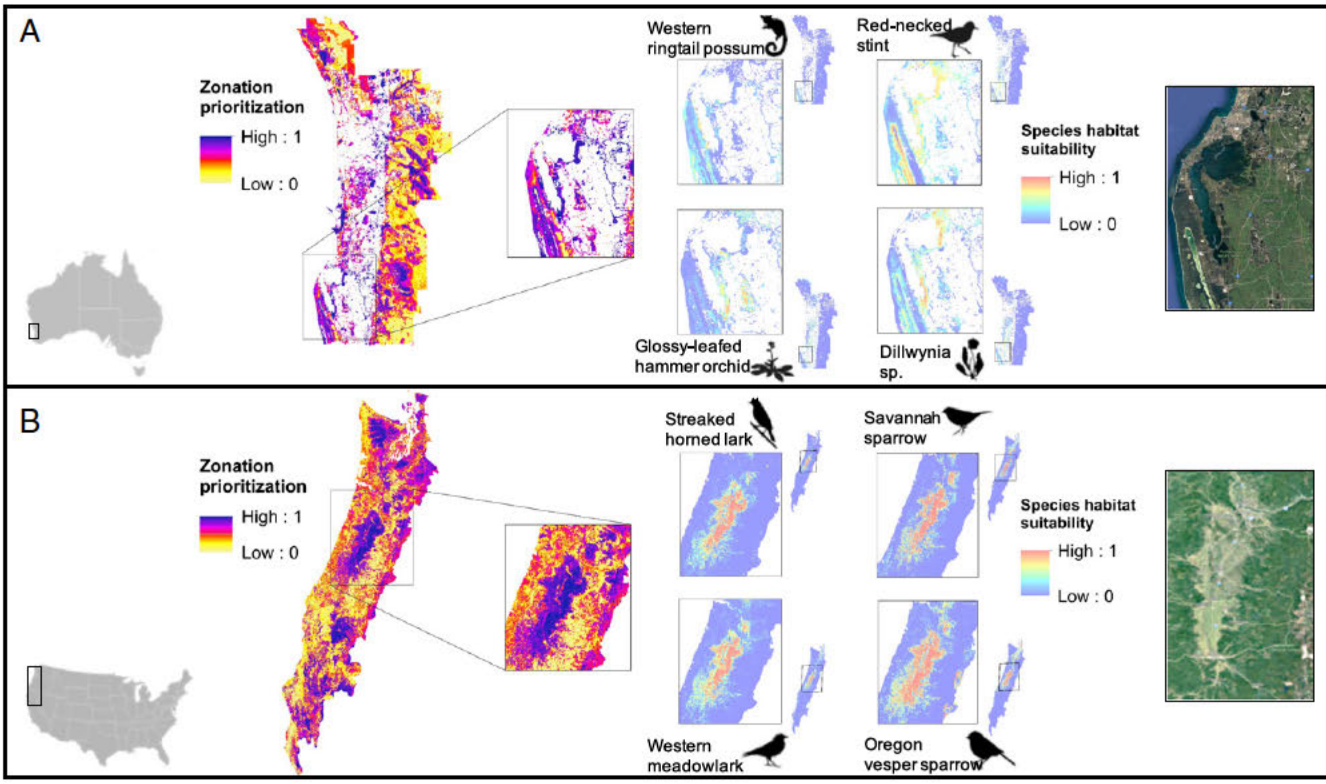

Fig. 2. Zonation priority rank maps (*Left*) are provided for two case studies: (*A*) Perth Australia and (*B*) Pacific Northwest United States showing the lowest (yellow) and highest (purple) conservation priority areas. Enlarged portions of the map (*Middle*) highlight fragmented parts of the study area that contain habitat patches of very high conservation value. The species icons indicate the species that have ranges primarily in those small, isolated patches. Maps adjacent to each species icon give SDM predictions for each of those species. Satellite images (*Right*) provide a bird's eye view of the level of habitat fragmentation in the featured case study subregions.

landscapes in western Australia and North America, where ~70% of the landscape contains intact forests and grasslands. The primary bias in this study is toward areas with relatively high quality biodiversity data suited to Zonation style analyses.

Conservation priorities are driven by more than the spatial distribution of biodiversity. Acquisition and management costs, social and political constraints, threats to biodiversity, and data uncertainty all play into conservation decisions. Our analysis indicates that an emphasis on larger, cheaper conservation areas may compromise biodiversity conservation objectives. If larger patches are cheaper to manage than small or isolated ones, then an explicit cost−benefit analysis could compare the efficiency gained by choosing larger patches to the cost of losing unique biodiversity values in small patches. Our aim here is not to argue for thoughtlessly prioritizing protection of small and isolated habitats, but rather to prompt a reassessment of assumptions about their lack of worth. When setting conservation priorities, application of rules that penalize small and isolated patches as a matter of course, without adequate assessment of value, should be avoided.

Our findings raise important questions for conservation practitioners. Our results are driven by our use of a biodiversity measure that emphasizes representativeness and complementarity (6). Does that mean that island biogeography and metapopulation theories are not relevant in conservation? Obviously not. However, the relative emphasis given to these two bodies of theory should reflect the specific objectives of a conservation program. A program seeking to ensure long term persistence of particular species would aim to preserve larger, more intact habitats for those species. However, if the aim is to ensure representation of a large number of species with diverse habitat needs, then it is appropriate to secure poorly represented environments, even if they comprise small and isolated patches, and especially if those patches face destruction. Biogeography and metapopulation theories underpin conservation and restoration efforts that seek species persistence, but they must be reconciled against the objective of achieving a representative and cost effective conservation estate.

Our unique attempt to draw some generality from spatial prioritizations conducted in diverse landscapes across the planet has provided insights into the relative importance of small and isolated habitat patches, and a statistical predictive framework for analyzing conservation importance. Our work provides a hypothesis that is testable and falsifiable with further evidence: that small and isolated patches of remnant habitat are likely to contain disproportionately more unique or rare biodiversity values that may be irreplaceable, compared with equivalent sized areas in highly intact landscapes. We encourage synthetic analyses such as ours to explore big questions of high practical relevance for the conservation of biodiversity.

Methods

Spatial Conservation Prioritization Case Studies. We synthesized and analyzed the results of 31 multispecies spatial conservation prioritization case studies from 28 countries around the globe, including case studies from Australia, North America, Africa, and Europe (*SI Appendix*, Table S1). The case studies presented in this study were all implemented using the systematic spatial prioritization software Zonation (7). Drawing on case studies that utilized a single decision support package allowed us to take a consistent approach to the definition of the "biodiversity value" across all studies. Landscape units were defined as raster map cells of 1 ha in size. A key criterion for inclusion in our synthesis was that studies must not have used arbitrary weighting of patches based on their size or level of fragmentation, such as the edge to area, patch size, or connectivity penalties commonly applied in conservation prioritization studies (38), as this would confound our attempts to understand the representativeness value of small isolated patches. The case studies analyzed conservation value across multiple biomes. All studies ranked conservation priorities across land scape units, using individual species distributions as the currency of conserva tion significance (*SI Appendix*, Table S1). No studies incorporated land acquisition or management costs in their Zonation prioritization. Based on these criteria, we identified four other studies that were not included in our analysis because authors could not be contacted or were not able to provide the necessary Zonation output files. Our aim was to achieve a geographically representative sample of Zonation studies, not a comprehensive analysis of the almost 1,000 studies that have utilized Zonation since 2005. We anticipate that many other studies could be added to our analysis in the future.

Conservation Value. The conservation value of a given landscape unit (raster cell) was defined in terms of its conservation priority rank, as determined by a Zonation analysis, that is based on the proportion of remaining species distributions contained within each cell. The ranking of cells in the landscape is created through a cell removal process whereby the Zonation software first assumes all cells in the landscape to be protected and then progressively removes cells that cause the smallest marginal loss in overall conservation value. This is repeated until no cells are left, with the least valuable grid cells being removed first and the most valuable cells being retained until the very end. The cell removal order provides the relative ranking. The critical com ponent of the algorithm is the definition of marginal loss (6) that dictates which grid cell is removed at each step of the process. There are multiple marginal loss functions that can be used in Zonation. The commonly used "core area" marginal loss function aims to balance the solution across all features (species and/or ecosystem types) at each removal step, retaining the high quality locations for all features as long as possible. Mathematically, the marginal loss in core area Zonation is defined as

$$\delta_i = \max_j \frac{w_j p_{ij}}{c_i \sum_{k \in S} p_{kj}}, \qquad [1]$$

where p_{ij} is the occurrence level of feature p_j in cell i, and $\Sigma_{k\in S} p_{kj}$ is the sum of occurrence levels (usually relative likelihood, probabilities of occurrence or population density) of species j in cells k that are included in the remaining set of cells S at each point of the cell removal process; w_j is the weight given to species j in the analysis, which is commonly set as uniform across all species or linked to species threat level, endemicity, or some other factor of conservation relevance (39). For completeness, we also include c_i, the cost of adding cell i to the reserve network. As cost was not used in the case studies incorporated in our analyses, this receives a value of 1 (equal cost for all grid cells). Using Eq. **1**, the software calculates the relative im portance of each cell for each feature (species or vegetation type) during the prioritization process. Then, for each cell, it identifies the maximum value across species and finally removes (ranks) the cell that has the smallest maximum value and, hence, the lowest marginal loss.

In most Zonation analyses, including those presented here, the currency of benefit is based on maps of habitat value for each species or vegetation community of interest. These are usually derived from observation data, species distribution models (SDMs), and/or maps of vegetation communities. Other values may be included, such as human social or economic values placed on particular places (e.g., refs. 7 and 40). However, here we focus on analyses conducted only with biodiversity features, predominantly species distributions derived from SDMs (31). Zonation can account explicitly for connectivity when prioritizing sites for conservation (38), including identifying suitable and effi cient corridors for maintaining connectivity between core areas of suitable habitat (39). Here we avoided studies that prioritized connectivity, to avoid confounding our statistical analysis. The top priority sites identified in the studies that underpin our analyses represent areas assumed to be necessary to ensure habitat representation for all species and vegetation communities.

Vegetation Patch Size, Shape, and Isolation Variables. Vegetation mapping of case study regions was used to define habitat patch size, shape, and isolation metrics for each region (*SI Appendix*, Table S2). Based on vegetation map ping, patches of habitat generally comprised areas of natural forest, woodland, shrubland, or grassland embedded in a matrix of human modified agricultural land thought to be unsuitable for the species in cluded in each case study. In some case studies, habitat was considered more broadly as any type of native or natural vegetation that could serve as habitat for species in the analysis (11), including agricultural areas with important natural features such as large scattered trees (35). Areas under intensive agriculture, industrial and urban areas, large water bodies, and transport corridors were considered nonhabitat for the purposes of our analysis. All species considered in case studies were terrestrial. Vegetation mapping and patch level variables were processed at 1 ha (100 m) grid cell resolution for all case study areas using patch delineation and size, shape, and isolation computation algorithms implemented in the R packages *raster* (v2.6 7) (41) and *SDMTools* (v1.1 221) (42) (see *SI Appendix*, Table S2 for definitions of patch variables computed and used in the analysis and *SI Appendix*, section S2 for R code to generate all patch variables). The original vegetation mapping included raster maps at resolutions ranging from 0.25 ha (50 m) to 6.25 ha (250 m) grid cell resolution, and some vector maps at mapping resolution ranging from 1:10,000 to 1:100,000. All vegetation maps not at 1 ha grid cell resolution were resampled to that resolution in R *raster*.

Analyzing Conservation Value in Relation to Patch Size, Shape, and Isolation Variables. The original grid cell resolution of Zonation case study analyses varied from 0.25 ha (New South Wales, Australia) to 1.5 km^2 (Europe) (*SI Appendix*, Table S2). For consistency, Zonation outputs in all case study re gions were resampled to 1 ha resolution and clipped using the R package *raster* to exactly match the grid cell resolution and extent of the vegetation mapping used to compute patch metrics.

Preliminary graphical exploration of the relationship between conservation value, patch size, and landscape fragmentation was conducted at a case study/country level to provide some insights into likely global level patterns. Zonation priority rank values were plotted against the patch variables planned for use in the statistical analysis, using box plots and scatter plots. Observed relationships were then explored in more detail using statistical modeling.

For global level statistical modeling, the dependent variable conservation value (Zonation rank) which ranges on a [0,1] scale, was transformed using a logit transformation to allow linear modeling assumptions to apply (43). In dependent variables (*SI Appendix*, Table S2) representing aspects of patch size, shape, fragmentation, and isolation were standardized to improve model parameter estimation. A Pearson's correlation matrix for all candidate independent variables was computed to allow identification of highly cor related pairs of independent variables, with the purpose of eliminating highly correlated variables being offered within the one statistical model; again, the purpose was to improve model coefficient estimation stability (*SI Appendix*, section S2) (44). From each pair of variables showing high corre lations ($\rho > 0.6$), one variable was retained for further modeling on the basis of univariate (a single independent variable) regressions against the de pendent variable (44). The variable from each correlated pair that most sub stantially reduced residual deviance in a univariate regression model (on conservation value) was the one that was retained. This resulted in a final set of four candidate patch level independent variables retained for potential inclusion in the final multiple regression model: patch area, patch fractal dimension, patch perimeter to area ratio, and proportion of intact vegetation in a 5 km radius. Patch area is simply the area, measured in hectares, of con tiguous natural vegetation that makes up the patch. Patch fractal dimension describes the shape complexity of each patch, with high values indicating high shape complexity. Patch perimeter to area ratio is used as an index of how much "internal" area of a patch exists relative to the amount of "edge." High ratios usually indicate long, thin strips of natural vegetation that are largely edge, with little internal area. The proportion of vegetation in a 5 km radius is computed by summing all of the 1 ha cells classed as natural vegetation in a 5 m radius around a focal cell (see *SI Appendix*, Table S2 for details of all patch variables, including those that made it to the final model selection stage).

Because ~290 million raster cells were available for regression modeling, we were forced to use a sparse sample of the available data to produce statistical models that converged with acceptable levels of spatial autocorrelation in model residuals (45). Using 10,000 random samples per case study region or country substantially reduced spatial autocorrelation in model residuals and provided sufficient data for stable inference. With 10,000 samples obtained from each case study region, the total sample for modeling was $n \approx 275{,}000$. Random sampling of the available data was repeated 10 times using an unweighted sampling scheme (10,000 from each region) to test for stable inference. Stable inference is defined here as low (<10%) coefficient of variation in estimates of coefficients (from models of the same structure) between independent samples obtained from each case study. Random samples from each case study region were obtained using the function *sampleRandom* in the R package *raster* (v2.6 7) (41). In all fitted models, residual autocorrelation was reduced to negligible levels by introducing an autocovariate term (45). The autocovariate was pro duced from the Zonation prioritization raster maps from each of the 31 studies using the R package *spdep* (v.0.6 5) (46) with a neighborhood radius of 20,000 cells and all other settings default (*SI Appendix*, section S2).

Global multivariable models were fitted as generalized linear models (GLMs) with a Gaussian link function (47). Nonlinear relationships observed in pre liminary graphical explorations of relationships between conservation value and patch metrics using smoothing terms (44) were accommodated in the global GLMs using quadratic or cubic polynomial terms. The final model structure (variables included and shapes of the responses) was determined utilizing backward selection implemented in the *StepAIC* function available in the *Mass* library in R (48). The backward selection function compares the full model (all terms included with cubic transformations and interactions between some independent variables) to smaller subsets on the basis of Akaike's Information Criteria (AIC) (49). AIC supports model selection based on a trade off between deviance reduction (explanatory power) and parsimony (50). The AIC best model arising from that process included a cubic transformation on all terms except interactions (essentially the full model) (*SI Appendix*, section S2). All variables included in the AIC best model were significant at $P < 0.01$ (*SI Appendix*, section S2). The tendency toward large models in this study is driven by the large sample of data used to fit each model. This is of little consequence, however, as smaller models (with fewer variables) give the same shape fits as larger models with respect to our main variables of interest (the patch level indices). Plots of independent variable effects on conservation value were produced using the *effects* package (51) (v4.0 1) in R (52).

Data and Software Availability. All statistical analyses were undertaken in R 3.3.3. All R code and raw data inputs (i.e., Zonation outputs and environmental layers) used in analyses are available (52) and via a weblink in *SI Appendix*, section S2.

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ATTACHMENT 3

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Jan		
Sample Size	2	1	4
Canada Goose	0.5	1	0.25
Mallard	0.5	0	0.75
Hooded Merganser	0	0	0.5
Common Merganser	0.5	0.0015	0.25
Pied-billed Grebe	0	0	0
Rock Pigeon	0	1	0.75
Eurasian Collared-Dove	0	0	0
Mourning Dove	0	0	0.75
Vaux's Swift	0	0	0
White-throated Swift	0	0	0
Anna's Hummingbird	0	1	1
Allen's Hummingbird	0	0	0
hummingbird sp.	0	0	0
American Coot	0	0	0
Killdeer	0	0	0
Ring-billed Gull	0	0	0
California Gull	0	0	0
Herring Gull	0	0	0
Glaucous-winged Gull	0	0	0
gull sp.	0	1	0
Double-crested Cormorant	0	0	0
Great Blue Heron	0.5	0	0
Great Egret	0	0	0.25
Snowy Egret	0.5	0.0015	0.25
Green Heron	0	0	0
Black-crowned Night-Heron	0	1	0
Turkey Vulture	0	0	0
Cooper's Hawk	0	0	0
Red-shouldered Hawk	0	0	0
Red-tailed Hawk	0.0015	1	0
Belted Kingfisher	0	1	0
Acorn Woodpecker	0	0	0
Downy Woodpecker	0	0	0.25
Nuttall's Woodpecker	0	0	0.75
Hairy Woodpecker	0	0	0.25
Downy/Hairy Woodpecker	0	0	0
Northern Flicker	0	0	0
American Kestrel	0	0	0
Peregrine Falcon	0	0	0
Pacific-slope Flycatcher	0	0	0
Empidonax sp.	0	0	0
Black Phoebe	1	1	0.5
Ash-throated Flycatcher	0	0	0
Western Kingbird	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Jan		
Cassin's Vireo	0	0	0
Warbling Vireo	0	0	0
Loggerhead Shrike	0	0	0
Steller's Jay	0	0	0
California Scrub-Jay	0	0	0
American Crow	0	0	0.25
Common Raven	0	0	0.25
Chestnut-backed Chickadee	0	1	0.75
Oak Titmouse	0	0	0
Northern Rough-winged Swallow	0	0	0
Tree Swallow	0	0	0
Violet-green Swallow	0	0	0
Barn Swallow	0	0	0
Cliff Swallow	0	0	0
swallow sp.	0	0	0
Bushtit	0.5	0	0
Wrentit	0	0	0
Ruby-crowned Kinglet	0	1	0.75
White-breasted Nuthatch	0	0	0.25
Brown Creeper	0	0	0
House Wren	0	0	0
Bewick's Wren	0	0	0
European Starling	0	0	0.25
Northern Mockingbird	0	0	0.5
Western Bluebird	0.5	0	0
Hermit Thrush	0	0	0.5
American Robin	0	0	0.25
Cedar Waxwing	0.5	1	0.75
House Sparrow	0.5	0	0.25
American Pipit	0	0	0.25
House Finch	0	0	0.25
Purple Finch	0	0	0
House/Purple Finch	0	0	0
Pine Siskin	0	0	0
Lesser Goldfinch	0	0	0
American Goldfinch	0	0	0.5
new world goldfinch sp.	0	0	0
Chipping Sparrow	0	0	0
Dark-eyed Junco	0	1	0.5
White-crowned Sparrow	0.5	0	0
Golden-crowned Sparrow	0	0	0
Song Sparrow	0	0	0
Lincoln's Sparrow	0	0	0
California Towhee	0.5	0	0
Spotted Towhee	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Jan		
sparrow sp.	0	0	0
Hooded Oriole	0	0	0
Bullock's Oriole	0	0	0
Red-winged Blackbird	0	0	0
Brown-headed Cowbird	0	0	0
Brewer's Blackbird	0	0	0
Great-tailed Grackle	0	0	0
blackbird sp.	0	0	0
Orange-crowned Warbler	0	0	0
Common Yellowthroat	0	0	0
Yellow Warbler	0	0	0
Yellow-rumped Warbler	1	1	1
Townsend's Warbler	0	0	0
Wilson's Warbler	0	0	0
Western Tanager	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Feb			
Sample Size	1	1	4	0
Canada Goose	0.0015	1	0.5	0.0015
Mallard	0.0015	1	1	0.0015
Hooded Merganser	0	0	0.25	0
Common Merganser	0.0015	0	0.75	0.0015
Pied-billed Grebe	0	0	0.25	0
Rock Pigeon	0.0015	1	0.25	0.0015
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	0	0	0.5	0
Vaux's Swift	0	0	0	0
White-throated Swift	0	0	0	0
Anna's Hummingbird	0.0015	0	0.75	0
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0
American Coot	0	0	0.25	0.0015
Killdeer	0	0	0.25	0
Ring-billed Gull	0	0	0.25	0
California Gull	0	0	0.25	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0	1	0.25	0
Double-crested Cormorant	0	0	0.0015	0.0015
Great Blue Heron	0	0	0.25	0.0015
Great Egret	0	0	0	0
Snowy Egret	0	0	0	0
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0	0	0
Turkey Vulture	0	0	0.25	0
Cooper's Hawk	0	0	0	0
Red-shouldered Hawk	0	1	0	0
Red-tailed Hawk	0	0	0.25	0
Belted Kingfisher	0	0	0	0
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0	0.0015	0.25	0
Nuttall's Woodpecker	0.0015	0	0	0
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0	0	0	0
Peregrine Falcon	0	0	0	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	1	1	1	0
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Feb			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0.25	0
California Scrub-Jay	0.0015	0.0015	0.25	0.0015
American Crow	1	1	0.75	0
Common Raven	0	0	0.25	0
Chestnut-backed Chickadee	1	0	1	0
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	0	0	0	0
Tree Swallow	0	0	0	0
Violet-green Swallow	0	0	0	0
Barn Swallow	0	0	0	0
Cliff Swallow	0	0	0	0
swallow sp.	0	0	0	0
Bushtit	0.0015	0	0.75	0
Wrentit	0	0	0	0
Ruby-crowned Kinglet	0	0	0.75	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0	1	0.5	0
European Starling	0.0015	0	0.25	0
Northern Mockingbird	0	0	0.25	0
Western Bluebird	0	0	0.25	0
Hermit Thrush	0	0	0.5	0
American Robin	0	0	0.75	0
Cedar Waxwing	0.0015	0	0.25	0
House Sparrow	0	1	0	0
American Pipit	0	0	0	0
House Finch	1	0.0015	0.75	0
Purple Finch	0	0	0.25	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	0	0	0.25	0
American Goldfinch	0	0	0.75	0
new world goldfinch sp.	0	0	0	0.0015
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	0.0015	0.0015	0.75	0
White-crowned Sparrow	0	0	0.25	0
Golden-crowned Sparrow	0	0	0.25	0
Song Sparrow	0	0	0.5	0
Lincoln's Sparrow	0	0	0	0
California Towhee	0	0.0015	0.5	0.0015
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Feb			
sparrow sp.	0	0	0	0
Hooded Oriole	0	0	0	0
Bullock's Oriole	0	0	0	0
Red-winged Blackbird	0	0	0.25	0
Brown-headed Cowbird	0	0	0	0
Brewer's Blackbird	0	0	0.25	0
Great-tailed Grackle	0	0	0.25	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0	0
Common Yellowthroat	0	0	0.25	0
Yellow Warbler	0	0	0	0
Yellow-rumped Warbler	0.0015	1	0.75	0
Townsend's Warbler	0.0015	0	0.25	0
Wilson's Warbler	0	0	0	0
Western Tanager	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Mar			
Sample Size	2	0	3	4
Canada Goose	0	0.0015	0.666667	1
Mallard	1	0	0.666667	0.75
Hooded Merganser	0	0	0	0
Common Merganser	1	0	0	0.25
Pied-billed Grebe	0	0	0	0
Rock Pigeon	0	0	1	0.75
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	0	0	0.666667	0.75
Vaux's Swift	0	0	0	0
White-throated Swift	0	0	0.333333	0.25
Anna's Hummingbird	0	0	0.666667	0.5
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0
American Coot	1	0	0	0.75
Killdeer	0	0	0.333333	0.5
Ring-billed Gull	0	0	0	0
California Gull	0	0	0	0
Herring Gull	0	0	0.333333	0.25
Glaucous-winged Gull	0	0	0	0
gull sp.	0	0	0	0.25
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0	0	0	0.25
Great Egret	0	0	0.333333	0.75
Snowy Egret	0	0	0	0.25
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0	0	0
Turkey Vulture	0	0	0	0.25
Cooper's Hawk	0	0	0	0.25
Red-shouldered Hawk	0	0	0.333333	0.25
Red-tailed Hawk	0	0	0.333333	0.25
Belted Kingfisher	0	0	0	0
Acorn Woodpecker	0	0.0015	0	0
Downy Woodpecker	0	0	0	0.5
Nuttall's Woodpecker	0	0	0.333333	0
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0	0	0	0
Peregrine Falcon	0	0	0	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	1	0.0015	0.666667	1
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Mar			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	0	0	0.333333	0.75
American Crow	1	0.0015	0.666667	1
Common Raven	0	0	0	0
Chestnut-backed Chickadee	0	0.0015	0.666667	0
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	0	0	0.333333	0.25
Tree Swallow	0	0	0	0.5
Violet-green Swallow	0	0	0	0
Barn Swallow	0	0	0	0
Cliff Swallow	0	0	0	0
swallow sp.	0	0	0	0
Bushtit	0	0	0.666667	0.25
Wrentit	0	0	0.0015	0
Ruby-crowned Kinglet	0	0	0.666667	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0	0	0.333333	0
European Starling	0	0	0.333333	0.75
Northern Mockingbird	0	0	0.333333	0.75
Western Bluebird	0	0	0.0015	0
Hermit Thrush	0	0	0	0
American Robin	0	0.0015	0.333333	0.75
Cedar Waxwing	0	0	0.666667	1
House Sparrow	0	0	0.333333	0.5
American Pipit	0	0	0	0
House Finch	0	0	0.666667	1
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0.25
Pine Siskin	0	0	0	0
Lesser Goldfinch	0	0	0.666667	0
American Goldfinch	0	0	0.333333	0
new world goldfinch sp.	0	0	0	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	0	0.0015	0.666667	0.5
White-crowned Sparrow	0	0	0.333333	0.25
Golden-crowned Sparrow	0	0	0	0
Song Sparrow	0	0	0	0.75
Lincoln's Sparrow	0	0	0	0
California Towhee	0	0	0.333333	0.75
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Mar			
sparrow sp.	0	0	0	0.25
Hooded Oriole	0	0	0	0
Bullock's Oriole	0	0	0	0
Red-winged Blackbird	0	0	0	0
Brown-headed Cowbird	0	0	0	0
Brewer's Blackbird	0	0	0	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0.0015	0
Common Yellowthroat	0	0	0	0
Yellow Warbler	0	0	0	0
Yellow-rumped Warbler	0	0	1	1
Townsend's Warbler	0	0	0	0
Wilson's Warbler	0	0	0	0
Western Tanager	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Apr			
Sample Size	2	1	2	1
Canada Goose	0.5	1	0.5	0
Mallard	1	0.0015	0	1
Hooded Merganser	0	0	0	1
Common Merganser	0	0	0.0015	0
Pied-billed Grebe	0	0	0	0
Rock Pigeon	1	1	0	1
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	0.5	0.0015	0	1
Vaux's Swift	0	0	0	0
White-throated Swift	0.5	0.0015	0	1
Anna's Hummingbird	1	1	0	1
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0
American Coot	0	0	0	0
Killdeer	0	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	0	0	0	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0.5	0	0	1
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0	0	0	0
Great Egret	0	0	0	0
Snowy Egret	0	0	0.5	0
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0	0	0
Turkey Vulture	0	0	0	0
Cooper's Hawk	0	0	0	0
Red-shouldered Hawk	0	1	0	0
Red-tailed Hawk	0	0	0	0
Belted Kingfisher	0	0	0	1
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0.5	0	0	1
Nuttall's Woodpecker	0	0	0	0
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0	0	0	0
Peregrine Falcon	0	0	0	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	0.5	1	0	1
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Apr			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	0.5	0.0015	0	1
American Crow	1	1	0	1
Common Raven	0	0	0	0
Chestnut-backed Chickadee	0.5	1	0	1
Oak Titmouse	0.5	0	0	0
Northern Rough-winged Swallow	0.5	0.0015	0.5	1
Tree Swallow	0	0	0	0
Violet-green Swallow	0	0	0	0
Barn Swallow	0.5	0	0.5	1
Cliff Swallow	0	0	0	1
swallow sp.	0.5	0	0	0
Bushtit	1	1	0	1
Wrentit	0	0	0	0
Ruby-crowned Kinglet	0.5	0	0	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0.5	0.0015	0	1
European Starling	0.5	0.0015	0	1
Northern Mockingbird	0.5	0.0015	0	1
Western Bluebird	0.5	0	0	1
Hermit Thrush	0.5	0	0	0
American Robin	1	1	0	1
Cedar Waxwing	0.5	0.0015	0	1
House Sparrow	0.5	0	0	1
American Pipit	0	0	0	0
House Finch	1	1	0	1
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	0.5	0.0015	0	1
American Goldfinch	0.5	0	0	1
new world goldfinch sp.	0	0	0	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	0.0015	1	0	0
White-crowned Sparrow	0.5	0.0015	0	1
Golden-crowned Sparrow	0.5	0	0	1
Song Sparrow	0	0	0	1
Lincoln's Sparrow	0.5	0	0	0
California Towhee	0.5	1	0	1
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Apr			
sparrow sp.	0	0	0	0
Hooded Oriole	0	0	0	0
Bullock's Oriole	0.5	0	0	1
Red-winged Blackbird	0.5	0.0015	0	0
Brown-headed Cowbird	0.5	0.0015	0	1
Brewer's Blackbird	0.5	0.0015	0	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0	1
Common Yellowthroat	0	0	0	0
Yellow Warbler	0	0	0	0
Yellow-rumped Warbler	1	1	0	1
Townsend's Warbler	0.5	0	0	0
Wilson's Warbler	0	0	0	0
Western Tanager	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	May			
Sample Size	1	4	2	1
Canada Goose	1	1	1	1
Mallard	1	1	0.5	1
Hooded Merganser	0	0	0	0
Common Merganser	0	0	0	0
Pied-billed Grebe	0	0	0	0
Rock Pigeon	1	1	1	1
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	1	0.5	0.5	1
Vaux's Swift	0	0	0	0
White-throated Swift	0	1	0.5	0
Anna's Hummingbird	1	1	0.5	1
Allen's Hummingbird	0	0	0	1
hummingbird sp.	0	0	0	0
American Coot	0	0	0	0
Killdeer	0	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	0	0.5	0.5	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0	0	0	0
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0.0015	0	0	0
Great Egret	0	0	0	0
Snowy Egret	0	0	0	0
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0.25	0	0
Turkey Vulture	0	0	0	0
Cooper's Hawk	0	0	0	0
Red-shouldered Hawk	0	0.5	0	0
Red-tailed Hawk	0	0	0	0
Belted Kingfisher	1	0	0	0
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0	0.25	0	0
Nuttall's Woodpecker	0	0.5	0.5	0
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0	0.0015	0	0
Peregrine Falcon	0	0	0	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	1	1	1	1
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	May			
Cassin's Vireo	0	0.25	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	0	0.75	0.5	0
American Crow	0	1	0.5	0
Common Raven	0	0	0	0
Chestnut-backed Chickadee	1	0.75	0	1
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	1	0.75	1	1
Tree Swallow	0	0	0	0
Violet-green Swallow	0	0	0	0
Barn Swallow	0	0.25	0	0
Cliff Swallow	0	0.5	0.5	0
swallow sp.	0	0	0	0
Bushtit	1	1	1	1
Wrentit	0	0	0	0
Ruby-crowned Kinglet	0	0	0	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0.25	0	0
Bewick's Wren	0	0.75	1	0
European Starling	0	0.75	0.5	0
Northern Mockingbird	0	0.5	0.5	0
Western Bluebird	0	0.25	0	0
Hermit Thrush	0	0	0	0
American Robin	1	0.75	0.5	1
Cedar Waxwing	1	1	0.5	0
House Sparrow	0	0.25	0	0
American Pipit	0	0	0	0
House Finch	1	1	1	1
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	1	0.75	0	0
American Goldfinch	0	0	0	0
new world goldfinch sp.	0	0	0	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	1	0.5	0.5	0
White-crowned Sparrow	0	0	0	0
Golden-crowned Sparrow	0	0	0	0
Song Sparrow	0	0.5	0.5	0
Lincoln's Sparrow	0	0	0	0
California Towhee	0	1	0.5	0
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	May			
sparrow sp.	0	0	0	0
Hooded Oriole	0	0	0	0
Bullock's Oriole	0	0.25	0	0
Red-winged Blackbird	0	0.25	0	0
Brown-headed Cowbird	1	0.25	0.5	0
Brewer's Blackbird	0	0	0.5	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0.25	0	0
Orange-crowned Warbler	1	0	0	0
Common Yellowthroat	0	0	0	0
Yellow Warbler	0	0	0	0
Yellow-rumped Warbler	0	0	0.5	0
Townsend's Warbler	0	0	0	0
Wilson's Warbler	1	0.25	0	0
Western Tanager	0	0	0	1

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Jun			
Sample Size	4	1	0	0
Canada Goose	0.0015	0	0	0
Mallard	1	0	0	0
Hooded Merganser	0	0	0	0
Common Merganser	0.25	0	0	0.0015
Pied-billed Grebe	0	0	0	0
Rock Pigeon	0.75	0	0	0
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	0.5	0	0	0
Vaux's Swift	0	0	0	0
White-throated Swift	0.75	0	0	0
Anna's Hummingbird	1	1	0	0
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0
American Coot	0	0	0	0
Killdeer	0.5	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	0.25	0	0	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0.0015	0	0	0
Double-crested Cormorant	0.25	0	0	0
Great Blue Heron	0	0	0	0
Great Egret	0.25	0	0	0
Snowy Egret	0	0	0	0
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0	0	0
Turkey Vulture	0.25	0	0	0
Cooper's Hawk	0.25	0	0	0
Red-shouldered Hawk	0	0	0	0
Red-tailed Hawk	0	0	0	0
Belted Kingfisher	0	0	0	0
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0.25	0	0	0
Nuttall's Woodpecker	0.5	0	0	0
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0.25	0	0	0
Peregrine Falcon	0	0	0	0
Pacific-slope Flycatcher	0.25	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	0.75	1	0	0
Ash-throated Flycatcher	0.25	0	0	0
Western Kingbird	0.25	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Jun			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0.0015	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	0.25	0	0	0
American Crow	0.75	0	0	0
Common Raven	0.25	0	0	0
Chestnut-backed Chickadee	0.5	1	0	0
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	0.5	1	0	0
Tree Swallow	0.25	0	0	0
Violet-green Swallow	0.5	0	0	0
Barn Swallow	0.25	0	0	0
Cliff Swallow	0.75	0	0	0
swallow sp.	0	0	0	0
Bushtit	0.25	0	0	0
Wrentit	0.25	0	0	0
Ruby-crowned Kinglet	0	0	0	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0.25	0	0	0
European Starling	0.75	0	0	0
Northern Mockingbird	0.5	0	0	0
Western Bluebird	0.25	0	0	0
Hermit Thrush	0	0	0	0
American Robin	0.75	1	0	0
Cedar Waxwing	0.25	0	0	0
House Sparrow	0.5	0	0	0
American Pipit	0	0	0	0
House Finch	1	0	0	0
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	0.75	1	0	0
American Goldfinch	0	0	0	0
new world goldfinch sp.	0	0	0	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	0.25	1	0	0
White-crowned Sparrow	0	0	0	0
Golden-crowned Sparrow	0	0	0	0
Song Sparrow	0	0	0	0
Lincoln's Sparrow	0	0	0	0
California Towhee	0.75	0	0	0
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Jun			
sparrow sp.	0	0	0	0
Hooded Oriole	0.25	0	0	0
Bullock's Oriole	0	0	0	0
Red-winged Blackbird	0.25	0	0	0
Brown-headed Cowbird	1	1	0	0
Brewer's Blackbird	0	0	0	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0	0
Common Yellowthroat	0	0	0	0
Yellow Warbler	0	0	0	0
Yellow-rumped Warbler	0	0	0	0
Townsend's Warbler	0	0	0	0
Wilson's Warbler	0	0	0	0
Western Tanager	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	July			
Sample Size	4	1	1	1
Canada Goose	0	0	1	1
Mallard	0.5	0	0	1
Hooded Merganser	0	0	0	0
Common Merganser	0	0	0	0
Pied-billed Grebe	0	0	0	0
Rock Pigeon	0.75	1	0	1
Eurasian Collared-Dove	0	1	0	0
Mourning Dove	0	1	0	0
Vaux's Swift	0	0	0	0
White-throated Swift	0.25	0	0	0
Anna's Hummingbird	0.5	0	0	1
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0
American Coot	0	0	0	0
Killdeer	0.25	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	0	0	0	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0	0	0	0
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0	0	0	0
Great Egret	0.25	0	1	0
Snowy Egret	0	0	0	0
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0	0	0.0015
Turkey Vulture	0	1	0	0
Cooper's Hawk	0	0	0	0
Red-shouldered Hawk	0	0	0	1
Red-tailed Hawk	0	0	0	0
Belted Kingfisher	0	0	0	1
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0	0	0	0
Nuttall's Woodpecker	0	0	0	1
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0	1	0	0
Peregrine Falcon	0	0	0.0015	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	1	0	1	1
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	July			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	0	0	0	0
American Crow	0	0	0	1
Common Raven	0	0	0	0
Chestnut-backed Chickadee	0.25	0	0	1
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	0	0	1	1
Tree Swallow	0	0	0	0
Violet-green Swallow	0	1	0	0
Barn Swallow	0	0	0	0
Cliff Swallow	0	0	0	0
swallow sp.	0	0	0	0
Bushtit	0.25	0	0	1
Wrentit	0	0	0	0
Ruby-crowned Kinglet	0	0	0	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0.25	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0	0	0	1
European Starling	0	1	0	0
Northern Mockingbird	0	0	1	0
Western Bluebird	0	0	0	1
Hermit Thrush	0	0	0	0
American Robin	1	0	0	1
Cedar Waxwing	0	0	0	0
House Sparrow	0.5	0	0	0
American Pipit	0	0	0	0
House Finch	0.5	1	0	1
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	0	0	0	1
American Goldfinch	0	0	0	0
new world goldfinch sp.	0	0	0	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	1	0	0	1
White-crowned Sparrow	0	0	0	0
Golden-crowned Sparrow	0	0	0	0
Song Sparrow	0	0	0	0
Lincoln's Sparrow	0	0	0	0
California Towhee	0.5	0	0	1
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	July			
sparrow sp.	0	0	0	0
Hooded Oriole	0	0	0	1
Bullock's Oriole	0	0	0	0
Red-winged Blackbird	0	1	0	0
Brown-headed Cowbird	0.5	0	0	1
Brewer's Blackbird	0	0	0	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0	0
Common Yellowthroat	0	0	0	0
Yellow Warbler	0	0	0	0
Yellow-rumped Warbler	0	0	0	0
Townsend's Warbler	0	0	0	0
Wilson's Warbler	0	0	0	0
Western Tanager	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Aug			
Sample Size	1	0	1	4
Canada Goose	1	0	1	0
Mallard	1	0	1	0.25
Hooded Merganser	0	0	0	0
Common Merganser	0	0	0	0
Pied-billed Grebe	0	0	0	0
Rock Pigeon	0	0	1	1
Eurasian Collared-Dove	1	0	0	0.25
Mourning Dove	1	0	0	0.5
Vaux's Swift	0	0	0	0
White-throated Swift	1	0	0	0
Anna's Hummingbird	1	0	1	0.25
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0.25
American Coot	0	0	0	0
Killdeer	1	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	0	0	0	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0	0	0	0
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0	0	0	0
Great Egret	0	0	0	0
Snowy Egret	0	0	0	0
Green Heron	0.0015	0	0	0
Black-crowned Night-Heron	0	0	0	0
Turkey Vulture	0	0	0	0
Cooper's Hawk	0	0	0	0
Red-shouldered Hawk	1	0	0	0.25
Red-tailed Hawk	0	0	0	0
Belted Kingfisher	0	0	0	0
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0	0	1	0
Nuttall's Woodpecker	1	0	1	0
Hairy Woodpecker	0	0	1	0.25
Downy/Hairy Woodpecker	0	0	0	0.25
Northern Flicker	0	0	0	0
American Kestrel	0	0	0	0
Peregrine Falcon	0	0	1	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	0	0	1	1
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Aug			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	1	0	0	0
American Crow	1	0	1	0.5
Common Raven	0	0	0	0
Chestnut-backed Chickadee	1	0	1	0
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	0	0	0	0
Tree Swallow	0	0	0	0
Violet-green Swallow	0	0	0	0
Barn Swallow	1	0	0	0
Cliff Swallow	1	0	0	0
swallow sp.	0	0	0	0
Bushtit	1	0	1	0.25
Wrentit	0	0	0	0
Ruby-crowned Kinglet	0	0	0	0
White-breasted Nuthatch	1	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0	0	1	0
European Starling	1	0	0	0
Northern Mockingbird	1	0	0	0.25
Western Bluebird	1	0	1	0.5
Hermit Thrush	0	0	0	0
American Robin	0	0	0	0.25
Cedar Waxwing	0	0	0	0
House Sparrow	1	0	0	0.25
American Pipit	0	0	0	0
House Finch	1	0	1	0.75
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	1	0	1	0
American Goldfinch	0	0	0	0
new world goldfinch sp.	0	0	0	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	0.0015	0	1	0.25
White-crowned Sparrow	0	0	0	0
Golden-crowned Sparrow	0	0	0	0
Song Sparrow	1	0	0	0
Lincoln's Sparrow	0	0	0	0
California Towhee	1	0	1	0
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Aug				
sparrow sp.		0	0	0	0
Hooded Oriole		0	0	0	0
Bullock's Oriole		0	0	0	0
Red-winged Blackbird		0	0	0	0
Brown-headed Cowbird		0	0	0	0
Brewer's Blackbird		0	0	0	0
Great-tailed Grackle		0	0	0	0
blackbird sp.		0	0	0	0
Orange-crowned Warbler		0	0	0	0
Common Yellowthroat		0	0	0	0
Yellow Warbler		0	0	1	0
Yellow-rumped Warbler		0	0	0	0
Townsend's Warbler		0	0	0	0
Wilson's Warbler		0	0	0	0
Western Tanager		0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Sep			
Sample Size	2	1	2	4
Canada Goose	0.5	0	0	0.5
Mallard	0.0015	1	0	0.25
Hooded Merganser	0	0	0	0
Common Merganser	0	0	0	0
Pied-billed Grebe	0	0	0	0
Rock Pigeon	1	0	1	1
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	0.0015	1	0.5	0
Vaux's Swift	0.0015	0	0	0
White-throated Swift	0.5	0	0	0
Anna's Hummingbird	1	1	1	1
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0.25
American Coot	0	0	0	0
Killdeer	0	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	0.0015	0	0	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0	0	0	0
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0	0	0	0.25
Great Egret	0	0	0.5	0
Snowy Egret	0	0	0	0.25
Green Heron	0.0015	0	0	0
Black-crowned Night-Heron	0	0	0	0.25
Turkey Vulture	0.5	0	1	0.25
Cooper's Hawk	0	1	0	0
Red-shouldered Hawk	0	0	0	0
Red-tailed Hawk	0.0015	0	0	0
Belted Kingfisher	0	0	0	0
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0	0	0	0
Nuttall's Woodpecker	0	0	0.5	0.75
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0	0	0	0
Peregrine Falcon	0	0	0	0
Pacific-slope Flycatcher	0	0	0.5	0
Empidonax sp.	0	0	0	0.25
Black Phoebe	1	1	1	1
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Sep			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0.0015	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	0	0	0.5	0.25
American Crow	0.5	0	0	0.25
Common Raven	0	0	0	0
Chestnut-backed Chickadee	1	1	1	0.75
Oak Titmouse	0	0	0	0.25
Northern Rough-winged Swallow	0	0	0	0
Tree Swallow	0	0	0	0
Violet-green Swallow	0	0	0	0
Barn Swallow	0	0	0	0
Cliff Swallow	0	0	0	0
swallow sp.	0	0	0	0
Bushtit	1	1	1	0.25
Wrentit	0	0	0	0
Ruby-crowned Kinglet	0	0	0	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0	1	0	0.25
European Starling	0	0	0.5	0
Northern Mockingbird	0	0	0	0
Western Bluebird	0.5	1	0	0.0015
Hermit Thrush	0	0	0	0
American Robin	0	1	0.5	0.5
Cedar Waxwing	0	0	0	0
House Sparrow	0	0	0	0
American Pipit	0	0	0	0
House Finch	1	1	0.5	0.75
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	0.0015	1	0.5	0.25
American Goldfinch	0	0	0	0
new world goldfinch sp.	0	0	0.5	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	0.5	1	0.5	0.25
White-crowned Sparrow	0	0	0	0
Golden-crowned Sparrow	0	0	0	0
Song Sparrow	0	0	0	0
Lincoln's Sparrow	0	0	0	0
California Towhee	0.5	0	0.5	0.25
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Sep			
sparrow sp.	0	0	0	0
Hooded Oriole	0	0	0	0
Bullock's Oriole	0	0	0	0
Red-winged Blackbird	0	0	0	0
Brown-headed Cowbird	0	0	0	0
Brewer's Blackbird	0	0	0	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0	0
Common Yellowthroat	0	0	0	0
Yellow Warbler	0	0	0.5	0.25
Yellow-rumped Warbler	0	0	0	0
Townsend's Warbler	0	0	0	0
Wilson's Warbler	0	0	0	0.25
Western Tanager	0.5	0	0.5	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Oct			
Sample Size	2	0	3	1
Canada Goose	0.5	0	0.333333	0.0015
Mallard	0	0	1	1
Hooded Merganser	0	0	0	0
Common Merganser	0	0	0	0
Pied-billed Grebe	0	0	0	0
Rock Pigeon	1	0	1	1
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	0	0	0.333333	0.0015
Vaux's Swift	0	0	0	0
White-throated Swift	0	0	0	0
Anna's Hummingbird	1	0	1	1
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0
American Coot	0	0	0	0
Killdeer	0	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	0	0	0.333333	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0	0	0	0
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0	0	0	1
Great Egret	0	0	0	1
Snowy Egret	0	0	0	0
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0	0	0
Turkey Vulture	0	0	0	0
Cooper's Hawk	0	0	0.333333	0
Red-shouldered Hawk	0	0	0	1
Red-tailed Hawk	0	0	0	0
Belted Kingfisher	0	0	0	0
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0	0	0	0
Nuttall's Woodpecker	0	0	0.333333	0
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0	0
American Kestrel	0	0.0015	0	0.0015
Peregrine Falcon	0	0	0	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	1	0	1	1
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Oct			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	0	0	0.333333	0
American Crow	0.5	0	0.666667	0
Common Raven	0	0	0	0
Chestnut-backed Chickadee	1	0	0.333333	1
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	0	0	0	0
Tree Swallow	0	0	0	0
Violet-green Swallow	0	0	0	0
Barn Swallow	0	0	0	0
Cliff Swallow	0	0	0	0
swallow sp.	0	0	0	0
Bushtit	0.5	0	0	1
Wrentit	0	0	0	0.0015
Ruby-crowned Kinglet	0	0	0	0
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0
House Wren	0	0	0	0
Bewick's Wren	0	0	0.333333	0
European Starling	0	0	0.333333	0
Northern Mockingbird	0	0	0.333333	0
Western Bluebird	0	0	0	1
Hermit Thrush	0	0	0.333333	0
American Robin	0.5	0	0.333333	1
Cedar Waxwing	0	0	0	0
House Sparrow	0	0	0	0
American Pipit	0	0	0	0
House Finch	0.5	0	0.666667	0
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	0.5	0	0.333333	0
American Goldfinch	0	0	0.333333	0
new world goldfinch sp.	0	0	0.333333	0
Chipping Sparrow	0	0.0015	0	0
Dark-eyed Junco	0.5	0	0	0
White-crowned Sparrow	0	0.0015	0.333333	0
Golden-crowned Sparrow	0	0	0.333333	0
Song Sparrow	0	0	0	0
Lincoln's Sparrow	0	0	0	0
California Towhee	0.5	0	0.333333	1
Spotted Towhee	0.5	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Oct			
sparrow sp.	0	0	0	0
Hooded Oriole	0	0	0	0
Bullock's Oriole	0	0	0	0
Red-winged Blackbird	0	0	0	0
Brown-headed Cowbird	0	0	0	0
Brewer's Blackbird	0.5	0	0.333333	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0	0
Common Yellowthroat	0	0	0	0
Yellow Warbler	0.5	0	0	0
Yellow-rumped Warbler	0	0	1	1
Townsend's Warbler	0	0	0	0
Wilson's Warbler	0	0	0	0
Western Tanager	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Nov			
Sample Size	1	1	0	5
Canada Goose	0	0	0.0015	0.2
Mallard	0	0	0.0015	0.6
Hooded Merganser	0	0	0.0015	0
Common Merganser	0	0	0	0
Pied-billed Grebe	0	0	0.0015	0
Rock Pigeon	1	0	0	0.2
Eurasian Collared-Dove	0	0	0	0
Mourning Dove	0	0	0	0.4
Vaux's Swift	0	0	0	0
White-throated Swift	0	0	0	0
Anna's Hummingbird	1	1	0	0.2
Allen's Hummingbird	0	0	0	0
hummingbird sp.	0	0	0	0
American Coot	0	0	0.0015	0.4
Killdeer	0	0	0	0
Ring-billed Gull	0	0	0	0
California Gull	1	0	0	0
Herring Gull	0	0	0	0
Glaucous-winged Gull	0	0	0	0
gull sp.	0	0	0.0015	0
Double-crested Cormorant	0	0	0	0
Great Blue Heron	0	0	0.0015	0.2
Great Egret	0	0	0.0015	0
Snowy Egret	0	0	0.0015	0
Green Heron	0	0	0	0
Black-crowned Night-Heron	0	0	0	0
Turkey Vulture	0	0	0	0
Cooper's Hawk	0	0	0	0
Red-shouldered Hawk	0	0	0	0
Red-tailed Hawk	0	0	0	0.2
Belted Kingfisher	0	0	0.0015	0
Acorn Woodpecker	0	0	0	0
Downy Woodpecker	0	0	0.0015	0
Nuttall's Woodpecker	1	0	0	0
Hairy Woodpecker	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0
Northern Flicker	0	0	0.0015	0
American Kestrel	0	0	0	0
Peregrine Falcon	0	0.0015	0	0
Pacific-slope Flycatcher	0	0	0	0
Empidonax sp.	0	0	0	0
Black Phoebe	1	0	0.0015	0.8
Ash-throated Flycatcher	0	0	0	0
Western Kingbird	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Nov			
Cassin's Vireo	0	0	0	0
Warbling Vireo	0	0	0	0
Loggerhead Shrike	0	0	0	0
Steller's Jay	0	0	0	0
California Scrub-Jay	1	0	0	0.2
American Crow	1	0	0.0015	0.2
Common Raven	0	0	0	0
Chestnut-backed Chickadee	0	1	0.0015	0.2
Oak Titmouse	0	0	0	0
Northern Rough-winged Swallow	0	0	0	0
Tree Swallow	0	0	0	0
Violet-green Swallow	0	0	0	0
Barn Swallow	0	0	0	0
Cliff Swallow	0	0	0	0
swallow sp.	0	0	0	0
Bushtit	1	1	0	0.2
Wrentit	0	0	0	0
Ruby-crowned Kinglet	1	0	0	0.2
White-breasted Nuthatch	0	0	0	0
Brown Creeper	0	0	0	0.2
House Wren	0	0	0	0
Bewick's Wren	0	0	0	0
European Starling	1	0	0	0.2
Northern Mockingbird	1	0	0	0
Western Bluebird	0	0	0	0
Hermit Thrush	0	0	0	0.2
American Robin	0	0	0.0015	0.4
Cedar Waxwing	0	0	0.0015	0.6
House Sparrow	0	1	0.0015	0
American Pipit	0	0	0	0
House Finch	1	0	0.0015	0
Purple Finch	0	0	0	0
House/Purple Finch	0	0	0	0
Pine Siskin	0	0	0	0
Lesser Goldfinch	1	0	0	0
American Goldfinch	1	1	0	0.2
new world goldfinch sp.	0	0	0	0
Chipping Sparrow	0	0	0	0
Dark-eyed Junco	0	0	0	0.2
White-crowned Sparrow	1	0	0.0015	0
Golden-crowned Sparrow	0	0	0.0015	0
Song Sparrow	0	1	0.0015	0
Lincoln's Sparrow	0	0	0	0
California Towhee	1	0	0.0015	0.2
Spotted Towhee	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Nov			
sparrow sp.	0	0	0	0
Hooded Oriole	0	0	0	0
Bullock's Oriole	0	0	0	0
Red-winged Blackbird	0	0	0	0
Brown-headed Cowbird	0	0	0	0
Brewer's Blackbird	0	0	0	0
Great-tailed Grackle	0	0	0	0
blackbird sp.	0	0	0	0
Orange-crowned Warbler	0	0	0	0
Common Yellowthroat	0	0	0	0
Yellow Warbler	0	0	0	0
Yellow-rumped Warbler	1	1	0	1
Townsend's Warbler	0	0	0	0
Wilson's Warbler	0	0	0	0
Western Tanager	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Dec				
Sample Size	2	1	1	5	0
Canada Goose	0.5	0	1	0.2	0
Mallard	1	0	1	0.4	0
Hooded Merganser	0	0	0	0	0
Common Merganser	0	0	0	0	0
Pied-billed Grebe	0	0	0	0	0
Rock Pigeon	1	0.0015	1	1	0
Eurasian Collared-Dove	0	0	0	0	0
Mourning Dove	1	0	0	0.2	0
Vaux's Swift	0	0	0	0	0
White-throated Swift	0.5	0.0015	0	0	0
Anna's Hummingbird	1	1	0	0.8	0
Allen's Hummingbird	0	0	0	0	0
hummingbird sp.	0	0	0	0	0
American Coot	0	0	0	0.2	0
Killdeer	0	0	0	0.2	0
Ring-billed Gull	0	0	0	0.2	0
California Gull	0	0	0	0.2	0
Herring Gull	0	0	0	0.2	0
Glaucous-winged Gull	0	0	0	0.2	0
gull sp.	0	0	0	0.4	0
Double-crested Cormorant	0	0	0	0	0
Great Blue Heron	0	0	0	0	0
Great Egret	0.5	0	0	0.2	0
Snowy Egret	0	0	0	0	0
Green Heron	0	0	0	0	0
Black-crowned Night-Heron	0	0	0	0	0
Turkey Vulture	0	0	0	0.2	0
Cooper's Hawk	0	0	0	0	0
Red-shouldered Hawk	0	0	1	0.2	0.0015
Red-tailed Hawk	0	1	0	0	0
Belted Kingfisher	0	0	0	0.4	0
Acorn Woodpecker	0	0	0	0	0
Downy Woodpecker	0	0.0015	1	0	0
Nuttall's Woodpecker	0	1	0	0.6	0
Hairy Woodpecker	0	0	0	0	0
Downy/Hairy Woodpecker	0	0	0	0	0
Northern Flicker	0.5	0	0	0	0
American Kestrel	0	0	0	0	0
Peregrine Falcon	0	0	0	0	0
Pacific-slope Flycatcher	0	0	0	0	0
Empidonax sp.	0	0	0	0	0
Black Phoebe	1	1	1	1	0
Ash-throated Flycatcher	0	0	0	0	0
Western Kingbird	0	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Dec				
Cassin's Vireo	0	0	0	0	0
Warbling Vireo	0	0	0	0	0
Loggerhead Shrike	0	0	0	0	0
Steller's Jay	0	0	0	0	0
California Scrub-Jay	0	0	0	0.4	0
American Crow	1	0.0015	0	0.6	0
Common Raven	0	0	0	0	0
Chestnut-backed Chickadee	1	0.0015	0	0.8	0
Oak Titmouse	0	0	0	0.0015	0
Northern Rough-winged Swallow	0	0	0	0	0
Tree Swallow	0	0	0	0	0
Violet-green Swallow	0	0	0	0	0
Barn Swallow	0	0	0	0	0
Cliff Swallow	0	0	0	0	0
swallow sp.	0	0	0	0	0
Bushtit	1	1	1	0.4	0
Wrentit	0	0	0	0	0
Ruby-crowned Kinglet	0.5	0	0	0.8	0
White-breasted Nuthatch	0	0	0	0	0
Brown Creeper	0	0	0	0	0
House Wren	0	0	0	0	0
Bewick's Wren	0	0	0	0.4	0
European Starling	0	0	0	0.4	0
Northern Mockingbird	0	0	0	0.4	0
Western Bluebird	0	0	0	0.2	0
Hermit Thrush	0.5	0	0	0.4	0
American Robin	0.5	1	1	0.2	0
Cedar Waxwing	1	1	0	0.8	0
House Sparrow	0	0	0	0.2	0
American Pipit	0	0	0	0	0
House Finch	1	0	0	0.8	0
Purple Finch	0.5	0	0	0	0
House/Purple Finch	0	0	0	0	0
Pine Siskin	0	0	0	0.2	0
Lesser Goldfinch	1	0	0	0.6	0
American Goldfinch	1	0	0	0.4	0
new world goldfinch sp.	0	0	0	0	0
Chipping Sparrow	0	0	0	0	0
Dark-eyed Junco	0	1	0	0.6	0
White-crowned Sparrow	0.5	0.0015	0	0.4	0
Golden-crowned Sparrow	0.5	0	0	0.2	0
Song Sparrow	0.5	0.0015	1	0.2	0
Lincoln's Sparrow	0	0	0	0.2	0
California Towhee	0.5	0.0015	1	0.4	0
Spotted Towhee	0	0	0	0	0

Frequency of observations in the selected location(s).:
Number of taxa: 104

	Dec				
sparrow sp.	0	0	0	0.2	0
Hooded Oriole	0	0	0	0	0
Bullock's Oriole	0	0	0	0	0
Red-winged Blackbird	0	0	0	0	0
Brown-headed Cowbird	0	0	0	0	0
Brewer's Blackbird	0	0	0	0.2	0
Great-tailed Grackle	0	0	0	0	0
blackbird sp.	0	0	0	0	0
Orange-crowned Warbler	0	0	0	0	0
Common Yellowthroat	0	0	0	0	0
Yellow Warbler	0	0	0	0	0
Yellow-rumped Warbler	1	1	1	1	0
Townsend's Warbler	0	0	1	0	0
Wilson's Warbler	0	0	0	0	0
Western Tanager	0.0015	0	0	0	0

ATTACHMENT 4

50 YEARS WITH IMPACT
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Riparian vegetation has disproportionate benefits for landscape-scale conservation of woodland birds in highly modified environments

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Summary

1. Identifying landscape patterns that allow native fauna to coexist with human land use is a global challenge. Riparian vegetation often persists in anthropogenic environments as strips of natural or semi-natural vegetation that provide habitat for many terrestrial species. Its relative contribution to landscape-scale conservation is likely to change as environments become increasingly modified. We used a 'whole of landscape' approach to test the hypothesis that riparian vegetation offers disproportionate benefits, relative to non-riparian vegetation, for the conservation of woodland birds in highly modified agricultural landscapes.

2. We selected 24 landscapes, each 100 km^2, along a gradient of landscape change represented by decreasing cover of native vegetation (from 60% to <2%), in an agricultural region in SE Australia. Bird species were systematically surveyed at three riparian and seven non-riparian sites in wooded vegetation in each landscape.

3. Riparian sites supported a greater richness of woodland-dependent species, a group of conservation concern, than did non-riparian sites. The composition of assemblages also differed between site types.

4. At the landscape scale, the pooled richness of bird assemblages at riparian and non-riparian sites, respectively, decreased with overall loss of tree cover despite constant sampling effort. Within landscapes, the β-diversity of woodland species among non-riparian sites increased (composition became less similar) as landscape tree cover declined. In contrast, riparian assemblages were relatively stable with no change in β-diversity. Importantly, as landscape tree cover declined, the proportion of woodland species uniquely present at riparian sites increased and made a greater contribution to overall landscape diversity.

5. *Synthesis and applications*. Landscape-scale richness of woodland species declines as landscape tree cover is lost. In highly depleted landscapes, riparian vegetation retains a relatively rich, stable assemblage compared with that in heterogeneous remnants of non-riparian vegetation and consequently contributes disproportionately to landscape-scale diversity. These observations, together with the diverse benefits of riparian vegetation for aquatic ecosystems, mean that protection and restoration of riparian vegetation is a high priority in anthropogenic environments. Importantly, such actions are directly amenable to individual land managers, and the benefits will accumulate to enhance the persistence and conservation of species at landscape and regional scales.

Key-words: agricultural environments, Australia, avifauna, β-diversity, countryside, farmland, γ-diversity, landscape, streamside, woodland birds

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Introduction

Riparian vegetation is a distinctive and ecologically important feature of landscapes throughout the world (Malanson 1993; Naiman & Decamps 1997). It has a critical role in diverse ecological processes such as filtering the flow of nutrients and pollutants into streams, regulating aquatic microclimates and providing organic input to aquatic food webs (Gregory *et al.* 1991; Naiman & Decamps 1997; Pusey & Arthington 2003). Riparian vegetation also benefits terrestrial biodiversity. Relative to the area it occupies, riparian vegetation provides habitat for a disproportionately large number of species (Redford & de Fonseca 1986; Naiman, Decamps & Pollock 1993; Knopf & Samson 1994). Plant and animal assemblages in riparian vegetation differ from those in adjacent environments, particularly those that are more arid, such that riparian zones enhance regional diversity (Sabo *et al.* 2005). Riparian vegetation may also support a greater richness and abundance of species than occurs in adjacent vegetation (Knopf & Samson 1994; Mac Nally, Soderquist & Tzaros 2000; Woinarski *et al.* 2000).

Riparian vegetation often persists in heavily modified landscapes as linear remnants of natural or semi natural vegetation. The role and value of such remnant vegetation in maintaining assemblages of plants and animals has been widely recognized, including in agricultural landscapes (Martin *et al.* 2006; Lees & Peres 2008), urban and suburban areas (Miller *et al.* 2003; Dallimer *et al.* 2012), tree plantations (Perry *et al.* 2011) and production forests (Marczak *et al.* 2010). These results have been derived largely from site based studies that compared the richness or composition of the biota at sites within riparian strips of different width (Hilty & Merenlender 2004; Perry *et al.* 2011) or management history (Jansen & Robertson 2001; Miller *et al.* 2003), or between riparian sites and those in adjacent non riparian vegetation (Palmer & Bennett 2006).

The relative influence of riparian vegetation on landscape scale patterns in biodiversity is less well known, although it is recognized as a key element in developing landscape and regional scale strategies for conservation (Naiman, Decamps & Pollock 1993; Knopf & Samson 1994; Woinarski *et al.* 2000). As environments become increasingly modified by humans, riparian zones may assume disproportionate importance relative to other landscape elements, due to the distinctiveness of their biota, their location in productive parts of the landscape and the potential connectivity they offer along environmental gradients (Bennett 1999; Sabo *et al.* 2005). On the other hand, riparian vegetation, as with other types of remnant vegetation, is influenced by its context and, due to its linear configuration, is exposed to edge effects that may result in simplified faunal communities (Miller *et al.* 2003; Martin *et al.* 2006) and a reduced ability to retain species in heavily modified landscapes. To draw inferences about the relative contribution of riparian vegetation to landscape scale conservation, it is necessary to compare riparian communities systematically across whole landscapes that have experienced different levels of anthropogenic change.

Here, we test the hypothesis that riparian vegetation has a disproportionately beneficial role, relative to non riparian vegetation, in maintaining landscape scale diversity of woodland birds in heavily modified landscapes. In southern Australia, the status of woodland dependent bird species is of conservation concern with many having experienced marked declines (Ford *et al.* 2001; Martin *et al.* 2012). We used a 'whole of landscape' approach (Bennett, Radford & Haslem 2006) to assess the relative importance of riparian and non riparian vegetation for bird species in 24 study landscapes chosen to represent a gradient in anthropogenic landscape change. We first examined assemblages at individual riparian and non riparian sites to compare their richness and composition and to identify species that favour either site type. Then, we pooled data within landscapes for each site type to address two main questions:

1. Are the pooled species richness and the between site diversity (β diversity) of riparian and non riparian assemblages, respectively, influenced by the degree of landscape modification?
2. Does the relative contribution of riparian vegetation to the landscape diversity of bird species vary along the gradient in landscape change?

Materials and methods

STUDY AREA

The study area encompasses *c.* 20 500 km^2 in Victoria, Australia, including parts of the inland slopes of the Great Dividing Range and the alluvial plains of the Victorian Riverina (Radford, Bennett & Cheers 2005). This region experiences hot, dry summers (mean daily maximum *c.* 30 °C) and mild winters. Mean annual rainfall (400 670 mm) increases from the NW to the SE of the region. Since European settlement in the mid 19th century, the environment has been profoundly altered by clearing for agriculture (cereal cropping, pastoralism, horticulture), logging of native forests and gold mining (ECC 1997). Less than 20% of the original extent of tree cover remains with much of this occurring on poorer soils of the inland slopes (ECC 1997).

Native vegetation of the region is dominated by eucalypt forests and woodlands (canopy height 10 25 m), with tree species composition varying in relation to topography, soils and moisture availability (ECC 1997). Dry forests dominated by grey box *Eucalyptus microcarpa*, red ironbark *E. tricarpa* and yellow gum *E. leucoxylon* are characteristic of the inland slopes, while on the lower slopes and plains, grassy woodlands dominated by grey box, yellow box *E. melliodora* and white box *E. albens* were formerly widespread but now occur as fragments. Riparian forests and woodlands along streams and floodplains are dominated by river red gum *E. camaldulensis* or, in drier environments to the north west, by black box *E. largiflorens*. Eucalypt woodlands in both riparian and non riparian areas have a similar open structure.

STUDY DESIGN

We selected 24 landscapes, each 10 × 10 km, that represented a gradient in tree cover (i.e. eucalypt forest and woodland) from *c.* 60% to <2% cover (Fig. 1) (see Radford, Bennett & Cheers 2005 for further details). Landscapes were selected to avoid towns and large wetlands and to minimize variation in vegetation composition and topography. In each landscape, 10 survey sites were established in remnant wooded vegetation, with at least two in each quarter of the landscape to ensure geographic spread of sampling. Three survey sites per landscape were allocated to riparian vegetation, and the remaining seven were stratified among other wooded elements large remnants (>40 ha), small remnants (<40 ha), roadside vegetation and scattered trees in proportion to their representation of tree cover in the landscape (Radford, Bennett & Cheers 2005). Potential sites were randomly positioned on vegetation maps, then checked in the field for suitability (e.g. access, vegetation type) and if appropriate were included.

Riparian vegetation ranges from broad stands (e.g. >100 m wide) adjacent to perennial rivers to narrow strips of trees of varying width along seasonally dry streams (typically first and second order streams). Much of the riparian vegetation is managed by private landholders through whose farms it extends, although some stream frontages (typically the larger rivers) are public land. Grazing by domestic stock (mostly sheep) is widespread, both historically and currently, and the original understorey vegetation has been highly modified. In each landscape, we located one riparian site along the stream with widest riparian vegetation and the other two sites were selected (*a priori* from maps) in different quarters of the landscape. Riparian sites were sections of linear streamside strips, typically part of a remnant network of riparian vegetation among farmland.

BIRD SURVEYS

We used a fixed width line transect of 2 ha (i.e. 400 × 50 m, or 500 × 40 m for some linear sites) to survey birds at each site (Radford, Bennett & Cheers 2005). Each survey included a 20 min period during which all individuals detected (seen or heard) were recorded as being either 'on' or 'off' the transect. Those foraging overhead (e.g. woodswallows, raptors) were noted separately but included as on transect. The observer then returned along the transect during a 10 min period, recording any additional species not detected during the first period. These supplementary records were regarded as off transect. As all sites have an open woodland structure, we assumed detectability of bird species was similar between site types. Analyses were based on the presence or absence of species on transects, rather than abundance estimates.

Surveys were conducted twice each in the breeding season (October November 2002 and 2003) and non breeding season (March April and June July 2003). The order of visiting sites was rotated between survey rounds such that each site was surveyed before 10:00 on at least two occasions. For each site, the data from the four survey visits were pooled. No more than five sites from the same landscape were surveyed on the same day. Two experienced observers surveyed each site twice during the study.

In this study, we only used records of species that were detected on transect, to ensure they were associated with a specific landscape element (e.g. riparian vegetation). We collated data for two categories of species. First, landbird species (hereafter 'landbirds') includes all species typical of north central Victoria after excluding waterbird species and species that are vagrants or marginal to the region. Secondly, woodland dependent species ('woodland species'), a subset of landbirds, are those associated with wooded vegetation for daily activities (foraging, roosting, nesting) and seldom observed in cleared farmland (Radford, Bennett & Cheers 2005). Nomenclature for bird species follows Christidis & Boles (2008).

DATA ANALYSES

Tree cover was used as a measure of wooded habitat. Tree cover was quantified by using a geographic information system and

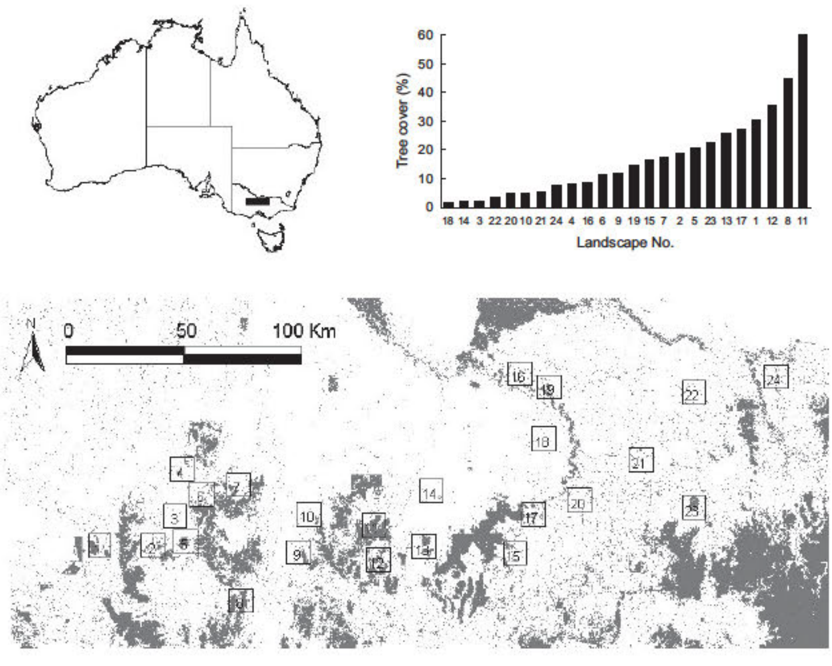

Fig. 1. The study area and study landscapes in northern Victoria (grey shading indicates tree cover) and histogram showing the variation in landscape tree cover (from Radford & Bennett 2007). The landscape number on the histogram corresponds with the label on the map.

digital tree cover map with a resolution of 10 × 10 m. Landscape tree cover (ha) was the summed total of all tree cover in a study landscape. Site tree cover (ha) was the summed total of all tree cover within a 250 m radius of the mid point of each transect: this area (19 6 ha) encompassed the transect (2 0 ha) and any adjacent or nearby wooded vegetation. Both measures of tree cover were log transformed for analyses.

At the site scale, we compared the species richness and com position of the avifauna between riparian and non riparian sites. We used a generalized linear mixed model (GLMM), with a Poisson distribution and log link function, to model species richness of landbirds and woodland species, respectively, in relation to the fixed effect of site type (riparian vs. non ripar ian) and site tree cover (ha). The latter variable was included so that differences between sites in riparian and non riparian vegetation could be distinguished from effects associated with the amount of vegetation in close proximity to a transect. Values for site tree cover were centred (mean 0) and stan dardized by dividing by two standard deviations to allow direct comparison of the relative effects of site type and tree cover on species richness (Gelman 2008). Landscape was incorporated as a random factor to account for spatial clustering of sites in study landscapes. An additional, site level random effect was included to account for further variance in the data than assumed by a Poisson distribution (Zuur, Ieno & Saveliev 2012). Model fit was assessed by using the marginal coefficient of determination ($R^2_{\mathrm{GLMM(m)}}$) (Nakagawa & Schielzeth 2013). GLMMs were fitted using the lme4 package (Bates, Maechler & Bolker 2012).

To compare the composition of assemblages between sites in riparian and non riparian vegetation, we adopted a model based approach for multivariate analysis, using the package mvabund (Wang *et al.* 2012). This approach fits a separate gen eralized linear model for each species, allowing the mean vari ance relationships of multivariate data to be modelled more accurately than techniques based on a matrix of pairwise mea sures such as Bray Curtis index (Warton, Wright & Wang 2012). It then uses resampling based hypothesis testing to make community level and taxon specific inference about which pre dictors have significant influence (Wang *et al.* 2012). Analyses were undertaken separately for landbirds and woodland species, to test whether there were compositional differences in assem blages in relation to two predictor variables, site type (riparian vs. non riparian) and site tree cover. A binomial distribution was specified to model the presence/absence of each species at each site, and the Wald statistic was used as the test statistic. Multivariate *P* values were calculated to assess compositional differences in relation to site type and site tree cover, based on 500 resamples using parametric bootstrapping (Wang *et al.* 2012). Univariate *P* values were calculated to identify individual species that showed significant relationships with predictors. *P* values were adjusted for multiple testing across species (Wang *et al.* 2012).

At the landscape scale, we compared the avifaunal assemblages of riparian and non riparian sites in three ways. First, we collated the pooled richness (γ diversity) of landbirds and woodland species, respectively, for the three riparian sites and for three ran domly selected, non riparian sites in the same landscape. To avoid bias in selection of three non riparian sites, we calculated the mean pooled richness of all possible combinations of three sites in each landscape (n 35). We used GLMs with a Gaussian distribution and identity link function to examine the relationship between γ diversity and landscape tree cover separately for each site type. Location of each landscape (easting) was included to control for geographic variation, known to influence assemblages (Radford, Bennett & Cheers 2005). Values for landscape tree cover and easting were standardized to allow direct comparisons of coefficients.

Secondly, we calculated between site diversity (β diversity) for assemblages at riparian and non riparian sites, respectively, in each landscape by using the asbio package (Aho 2013). We used the classical Whittaker measure for β diversity (Whittaker 1960; Anderson *et al.* 2011), where:

$$\beta\,\text{diversity} \quad (\gamma\ \text{diversity}/\text{mean}\ \alpha\ \text{diversity}).$$

For example, for riparian vegetation, β diversity was calculated for each landscape by dividing the pooled richness (γ diversity) of the three riparian sites by the mean richness (α diversity) of individual riparian sites. Beta diversity was then modelled, sepa rately for each site type, in relation to landscape tree cover (con trolling for geographic location) by using GLMs with identity link function.

Thirdly, we assessed the contribution of riparian vegetation to overall landscape diversity by using two complementary indices (Sabo & Soykan 2006).

1. The proportion of unique riparian species (R_{u}) is the number of species recorded only in riparian sites, as a proportion of the total landscape assemblage. It is given by:

$$R_{\mathrm{u}} \quad a/(a+b+c),$$

where a and b are the number of species unique to riparian and non riparian sites, respectively, and c is the number of species shared by the two site types.

2. The proportional increase in the landscape assemblage due to riparian sites (R_{add}) is the number of species unique to riparian sites as a proportion of the total species recorded at non riparian sites. It is given by:

$$R_{\mathrm{add}} \quad a/(b+c)$$

For each measure, we used regressions to model the relation ship with landscape tree cover, controlling for geographic loca tion (easting), to test the hypothesis that riparian vegetation makes a disproportionately greater contribution at lower tree cover. As the proportion of unique riparian species (R_{u}) is a true proportion, bound at zero and one, we used beta regression mod els with a logit link function (Ferrari & Cribari Neto 2004), gen erated using the betareg package (Cribari Neto & Zeileis 2010). To model the proportional increase in the landscape assemblage (R_{add}), we used a GLM with identity link function, as in this case the number of unique species is expressed as a proportion of the richness of a separate assemblage (i.e. of pooled non riparian sites) and therefore is not a true proportion (i.e. it can exceed one). Landscape scale models were checked for spatial autocorre lation using Moran's I test statistic at all neighbourhood distances. No significant spatial autocorrelation was found at any neighbourhood distance for the response variables after correct ing for multiple comparisons (see Appendix S2, Supporting infor mation).

All analyses were undertaken in R (version 2.11.1) (R Develop ment Core Team 2010). Variables were regarded as having a sig nificant influence on the response variable when the 95% confidence interval of the coefficient did not overlap with zero.

Results

In total, 126 species of landbirds, including 76 woodland species, were recorded on transects during the study. Most species occurred at sites in both riparian and non riparian vegetation: 83% of landbird species (104/126) and 82% of woodland species (62/76) were recorded at riparian sites, while for non riparian sites comparable figures were 92% and 91%, respectively. The frequency of occurrence of all species, at both site and landscape scales, is given in Appen dix S1 (Supporting Information). One nationally threa tened species (swift parrot *Lathamus discolor,* endangered) was recorded in 11 landscapes; many other species (e.g. grey crowned babbler *Pomatostomus temporalis*, diamond firetail *Stagonopleura guttata*, speckled warbler *Chthonicola sagittata*), though not nationally threatened, are of conser vation concern (Ford *et al.* 2001; Mac Nally *et al.* 2009).

COMPARISONS AT THE SITE SCALE

The species richness of all landbirds and woodland species differed between site types and increased with increasing site tree cover (Table 1). For a given level of site tree cover, riparian sites supported a greater richness than non riparian sites, with this disparity more marked for all landbirds than for woodland species.

The composition of landbird and woodland bird assem blages differed significantly between riparian and non riparian sites (landbirds, Wald statistic 26·38, *P* 0·001; woodland species, Wald 17·37, *P* 0·001), and also in relation to site tree cover (landbirds, Wald statis tic 26·63, *P* 0·001; woodland species, Wald 21·52, *P* 0·001). Differences in composition were driven pri marily by species that favoured riparian vegetation (Appendix S1, Supporting information). This included woodland species such as the sacred kingfisher *Todiram phus sanctus*, superb fairy wren *Malurus cyaneus*, and white plumed honeyeater *Lichenostomus penicillatus*, as well as landbird species such as rufous songlark *Cincloram phus mathewsi* and sulphur crested cockatoo *Cacatua galerita*. Compositional differences were also influenced by woodland species associated with non riparian vegetation (e.g. brown headed honeyeater *Melithreptus brevirostris*, rufous whistler *Pachycephala rufiventris*) (Appendix S1, Supporting information).

COMPARISONS AT THE LANDSCAPE SCALE

Pooled species richness of assemblages at riparian and non riparian sites showed similar trends: richness of both landbirds and woodland species decreased as landscape tree cover decreased (Table 2, Fig. 2). When comparing just the univariate relationship between pooled species richness and landscape tree cover, the fit of the model dif fered substantially between site types: R^2 values for ripar ian sites were 12·6% for landbirds and 19·1% for woodland species, while for non riparian sites it was 48·3% for landbirds and 55·6% for woodland species. Thus, as landscape tree cover is lost, there is a stronger relationship (size of the coefficient, Table 2) and more variance in richness is explained (R^2 values) for non ripar ian sites than for riparian sites.

Patterns of β diversity for riparian and non riparian sites showed contrasting responses to landscape change. For riparian sites, β diversity was not related to land scape tree cover or geographic location (easting), either for landbirds or woodland species (Table 3, Fig. 3). That is, the average contribution of individual riparian sites to the pooled richness of assemblages in riparian vegetation in each landscape did not change significantly as tree cover declined. In contrast, for non riparian sites, β diver sity of landbirds was positively related to landscape tree cover, while β diversity of woodland species was nega tively related to landscape tree cover (Table 3, Fig. 3). Thus, for non riparian sites, as landscape tree cover decreased, there was less variation between sites for land birds, but more variation between sites for woodland species (Fig. 3).

In each landscape, riparian sites supported numerous 'unique' species not recorded at non riparian sites in that

Table 1. Results from generalized linear mixed models of the relationship between species richness and site type (riparian, non riparian vegetation), controlling for site tree cover. For site type, the reference category is non riparian vegetation. Landscape was included as a random factor. Coefficients, *z* values (coefficient/standard error) and variance explained (R^2) are given for each model

Response	Model term	Coefficient	*z* value	$R^2_{GLMM(m)}$
Landbird species	Site tree cover (log)	0 272	7 65	38 1
	Site type: riparian	0 336	10 42	
Woodland species	Site tree cover (log)	0 965	13 13	51 3
	Site type: riparian	0 355	5 86	

Table 2. Models of the relationship between pooled species rich ness at riparian and non riparian sites, respectively, in each land scape in relation to landscape tree cover. Coefficients and t values (coefficient/standard error) are given for each model

		Riparian		Non-riparian	
Response	Predictors	Coefficient	*t*-value	Coefficient	*t*-value
Landbirds	Landscape tree cover (log)	3 45	2 38	4 33	3 32
	Easting	3 07	2 11	2 10	3 01
Woodland species	Landscape tree cover (log)	3 97	4 20	5 24	4 91
	Easting	3 59	2 03	1 99	1 86

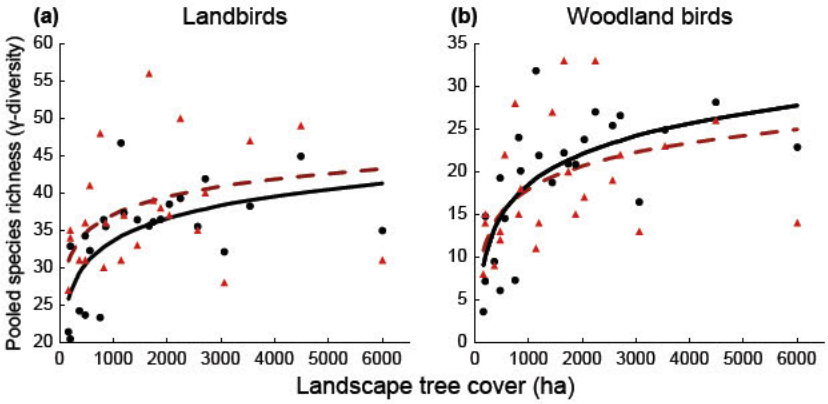

Fig. 2. Relationship between pooled spe cies richness for landbirds and woodland species, respectively, in study landscapes in relation to landscape tree cover. Fitted models and raw data are shown for ripar ian (dashed lines, triangles) and non ripar ian vegetation (solid lines, circles).

Table 3. Models of the relationship between β diversity of bird species for riparian and non riparian sites and landscape tree cover, con trolling for geographic location (easting). Coefficients, *t* values and variance explained (R^2) are given for each model

		Riparian sites			Non riparian sites		
Response	Variable	Coefficient	*t* value	R^2	Coefficient	*t* value	R^2
Landbirds	Landscape tree cover (log)	0 028	0 846	0 039	0 171	3 128	0 318
	Easting	0 019	0 568		0 037	0 671	
Woodland species	Landscape tree cover (log)	0 035	0 881	0 060	0 206	2 593	0 541
	Easting	0 038	0 950		0 277	3 485	

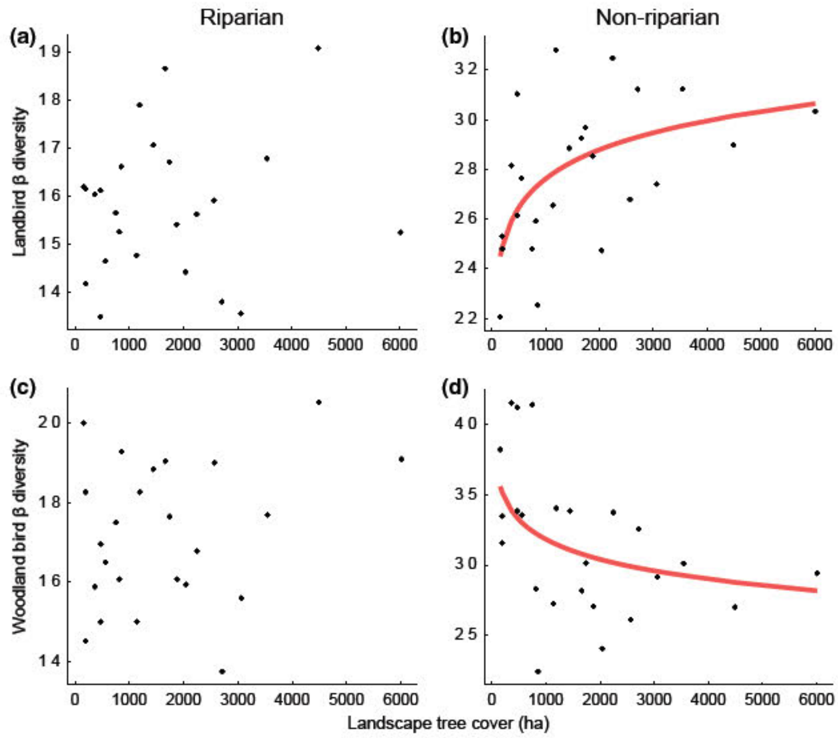

Fig. 3. Relationship between β diversity and landscape tree cover (ha) for landbirds at (a) riparian and (b) non riparian sites, and for woodland species at (c) riparian and (d) non riparian sites in 24 study land scapes. Fitted lines show the predicted values for significant relationships (solid circles represent observed values for each landscape.

landscape. For landbirds, a mean of 10·2 (range 5 27) spe cies per landscape occurred uniquely at riparian sites, repre senting on average 17·2% of the landscape assemblage. For woodland species, a mean of 5·6 species (range 0 22) per landscape, or 18·0% of the woodland species assemblage, occurred uniquely at riparian sites. Species consistently occurring as unique (i.e. in ≥5 landscapes) included 13 spe cies of landbird (of which eight were woodland species), most significantly associated with riparian vegetation (Appendix S1, Supporting information).

The proportion of unique riparian species (R_u) varied geographically with a greater proportion in landscapes to the east (Table 4). For woodland species, there was a sig nificant negative relationship with landscape tree cover (Table 4, Fig. 4a). Thus, in depleted low cover landscapes, riparian vegetation supported a proportionally larger number of unique woodland species, not otherwise recorded in the landscape. For landbirds, there was a similar, but non significant relationship (Table 4).

The percentage increase in the landscape assemblage (R_{add}) due to species unique to riparian sites ranged from 4·3 to 79·4% (mean 22·2%) for landbirds, and for woodland species 0·0 to 169·2% (mean 27·3%). One landscape (Black Dog Creek) was an outlier, particularly for woodland species, with a percentage increase (169·2%) more than four standard deviations from the mean. It was excluded from further analyses. Variation among landscapes in the percentage increase due to riparian sites was positively related to easting (Table 4). For woodland species, it was negatively related to landscape tree cover (Table 4, Fig. 4b), while for landbirds a similar but non significant trend was evident. Hence, riparian sites added proportionally more to landscape richness in those land scapes that had experienced greater loss of tree cover.

Discussion

We used a 'whole of landscape' approach to examine the value of riparian vegetation to the landscape scale conser vation of bird assemblages in modified agricultural envi ronments. A key finding was that riparian vegetation enhanced diversity at the landscape scale by supporting unique species additional to those recorded in non riparian vegetation. This contribution was relatively greater in the most depleted landscapes, consistent with the hypothesis that riparian vegetation has disproportionate benefits for conservation in highly modified environments.

RIPARIAN VEGETATION SITE SCALE

In our study area, riparian sites supported both more and different species compared with non riparian sites. A greater species richness of woodland birds at riparian sites has also been observed in other studies (e.g. Mac Nally, Soderquist & Tzaros 2000; Palmer & Bennett 2006) but is not necessarily true in all situations (McGarigal & McComb 1992). Compositional differences, however, con sistently occur for a wide range of taxa across multiple continents (Sabo *et al.* 2005).

While woodland bird species are of conservation con cern in southern Australia (Ford *et al.* 2001), the value of riparian vegetation for other species is also important. First, a number of other landbird species were strongly associated with riparian vegetation (Appendix S1, Sup porting information). Secondly, other landbirds are also vulnerable to environmental change: notably, they were equally represented with woodland species among the two thirds of species that experienced regional decline associated with a decade of severe drought (Mac Nally *et al.* 2009). Thirdly, common species have an important place in shaping ecosystems, through their contribution to the structure of communities and role in ecological inter actions (Gaston & Fuller 2008). Finally, such species include many common birds that landholders regularly

Table 4. Models of the contribution of riparian sites to landscape richness in relation to landscape tree cover, controlling for geographic location (easting). Two indices were used: (a) the proportion of unique riparian species (R_u) and (b) the proportional increase in the landscape assemblage (R_{add}). See Materials and methods for further details

		Proportion unique riparian (R_u)			Proportional increase (R_{add})		
Response	Predictors	Coefficient	*z* value	R^2	Coefficient	*t* value	R^2
Landbirds	Tree cover	0 127	1 576	0 53	0 025	0 947	0 40
	Easting	0 334	4 099		0 088	3 316	
Woodland species	Tree cover	0 395	2 843	0 31	0 077	3 109	0 59
	Easting	0 757	5 220		0 095	3 548	

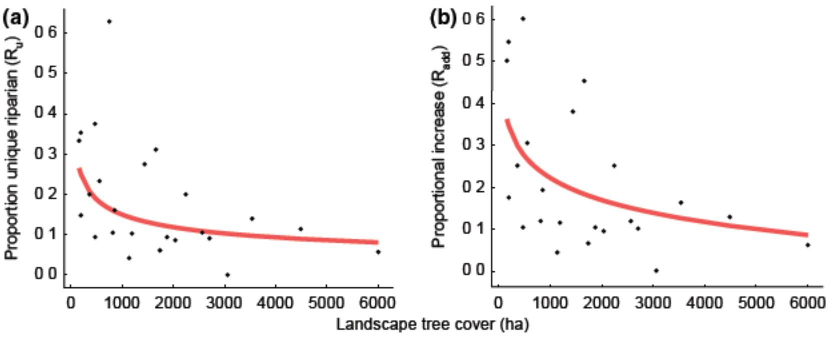

Fig. 4. Relationship between (a) propor tion of unique riparian species (R_u) and (b) proportional increase in landscape assem blages due to riparian sites (R_{add}), and landscape tree cover (ha) for woodland spe cies. The fitted lines show predicted values; solid circles represent observed values for each landscape.

encounter, including iconic species such as the laughing kookaburra *Dacelo novaeguineae*, and are important in motivating conservation efforts on private land.

RIPARIAN VEGETATION LANDSCAPE SCALE

There were two notable patterns at the landscape scale. First, as landscape tree cover was lost, the pooled richness of bird assemblages declined, despite a constant sampling effort in each landscape. This relationship was stronger for assemblages in non riparian vegetation than in riparian vegetation. Thus, the bird assemblages of riparian vegetation in the study landscapes were less sensitive to the changing landscape context. Secondly, for woodland bird species, as landscape tree cover declined, assemblages in riparian vegetation made a proportionally greater contribution to the overall landscape diversity of woodland species. That is, there were proportionally more species unique to riparian sites in the more depleted landscapes. A similar, but non significant, trend was also evident for all landbirds.

The mechanism for this disproportionate contribution of riparian vegetation in highly modified landscapes was revealed by patterns of β diversity in the study landscapes, which differed markedly between riparian and non riparian sites. For riparian sites, β diversity of both woodland species and landbirds did not vary significantly along the gradient in landscape tree cover. In both low cover and high cover landscapes, the average contribution of individual riparian sites to the pooled richness of birds in riparian vegetation did not differ.

In contrast, for non riparian sites, β diversity displayed significant but opposite trends for all landbirds and woodland species as landscape tree cover declined. With decreasing tree cover, β diversity of landbirds became lower (i.e. assemblages more similar), while for woodland species it became higher (assemblages less similar). These results can be attributed to greater heterogeneity of non riparian sites in depleted landscapes. Non riparian sites included large and small remnants, roadsides and scattered trees. With decreasing landscape tree cover, wooded vegetation became dominated by small remnants, roadsides and scattered trees and sample sites were allocated accordingly (Radford, Bennett & Cheers 2005). Generalist species that tolerate or favour modified environments persist in the landscape despite increasing change, whereas woodland specialists occur at fewer and fewer sites. Thus, there is a homogenization of the overall landbird community in non riparian vegetation due to the prevalence of generalist species (i.e. β diversity decreases), but concurrently, there is an increase in between site variability of woodland species (i.e. β diversity increases) as they become increasingly rare and thereby stochastic in their occurrence.

Overall, the key role of riparian vegetation in highly modified environments can be attributed to the relatively higher species richness and consistency of assemblages between sites, contrasting with non riparian sites which become increasingly dominated by impoverished assemblages of generalist species associated with more heterogeneous landscape elements. Consequently, in depleted landscapes, the proportion of species unique to riparian vegetation is higher and the proportional contribution to landscape diversity is greater. However, not all species regularly occur in riparian vegetation: many woodland species are more strongly associated with non riparian woodlands, which have a complementary role in maintaining the overall assemblage.

In what way does riparian vegetation differ from non riparian vegetation that accounts for the disproportionate benefits it provides? Riparian vegetation occurs in productive parts of the landscape on more fertile soils with greater availability of water, resulting in greater structural complexity of the vegetation and more reliable and abundant food resources (e.g. nectar, seeds, invertebrates) (Woinarski *et al.* 2000; Palmer & Bennett 2006). Riparian vegetation frequently has large old trees, which in turn give rise to tree hollows and coarse woody debris (e.g. Mac Nally, Soderquist & Tzaros 2000), which provide nesting and foraging resources used by many bird species.

It is important to recognize several caveats associated with this study. First, the riparian sites were remnants, typically surrounded by cleared farmland used for grazing stock or cropping. Some were broad swathes on public land adjacent to rivers, and many were narrow strips through farmland, but they were not riparian zones embedded within continuous dryland forest. In the latter situation, riparian vegetation will have greater value for woodland species as it is not exposed to farmland edges and there is greater opportunity for movement between adjacent riparian and non riparian habitats. Consequently, it is likely that this study has underestimated the potential contribution of riparian vegetation to landscape diversity.

Secondly, we did not incorporate in analyses the variation among sites associated with land management and habitat attributes (e.g. density and size of trees, ground layer complexity), which reflect variation in habitat quality. These attributes may explain further variation in patterns of occurrence of species (Mac Nally, Soderquist & Tzaros 2000; Jansen & Robertson 2001).

Thirdly, our aim was to examine the relative contribution of riparian vegetation to avifaunal conservation along a gradient of anthropogenic land use. We systematically surveyed and compared assemblages from a fixed number of sites in riparian and non riparian vegetation, in landscapes representing a gradient of decreasing tree cover. The absolute contribution of riparian vegetation to landscape diversity is likely to be influenced by additional factors, for example the total area of riparian vs. non riparian vegetation, the connectivity of riparian vegetation, and the number of streams and their spatial arrangement in the landscape. Riparian vegetation is subject to more stringent controls in relation to logging and tree clearance, such that as total tree cover declines, the proportion of the total vegetation accounted for by riparian vegetation increases. Thus, the absolute contribution of riparian vegetation is likely to be greater than the relative contribution reported in this study.

IMPLICATIONS FOR CONSERVATION AND MANAGEMENT

Globally, the conservation of biodiversity depends fundamentally on the extent to which species can persist within human dominated environments particularly agricultural lands which increasingly dominate Earth's surface (Foley *et al.* 2005). Much attention has been given to factors that influence the persistence of species in agricultural landscapes: for example, the importance of heterogeneity (Benton, Vickery & Wilson 2003), keystone structures (Tews *et al.* 2004), connectivity (Bennett 1999), and the extent and pattern of native vegetation (Bennett, Radford & Haslem 2006). Riparian vegetation not only contributes to each of these themes, but has a critical role in ecological processes linking aquatic and terrestrial environments and the provision of ecosystem services for humans (Gregory *et al.* 1991; Naiman & Decamps 1997). Consequently, the protection, management and restoration of riparian vegetation is a high priority in conservation strategies for anthropogenic environments.

A key point is that the management and restoration of riparian vegetation is amenable to the scale of action of individual land managers or community groups, and their combined actions will have cumulative benefits at the landscape or catchment scale. Three types of measures can be readily identified. First, increasing the width of riparian vegetation will increase the richness of assemblages (Hilty & Merenlender 2004; Lees & Peres 2008; this study). Increased width can be achieved by restoring adjacent vegetation, infilling vegetation across bends in streams or by *a priori* planning to retain wide strips. Secondly, enhancing the connectivity of riparian vegetation for terrestrial biota can be achieved by preventing 'breaks' in vegetated strips or by restoration to fill such 'gaps'. Thirdly, managing the composition and structure of riparian vegetation can increase its quality as faunal habitat: for example, by controlling degrading processes such as intensive stock grazing (Jansen & Robertson 2001) and by promoting structural complexity (e.g. large trees, logs, vegetation heterogeneity).

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Supporting Information

Additional Supporting Information may be found in the online version of this article.

Appendix S1. Summary of all landbirds and woodland dependent species and their frequency of occurrence in riparian and non riparian sites.

Appendix S2. Summary of *P* values for Moran's I tests for spatial autocorrelation of response variables at multiple neighbourhood distances.

ATTACHMENT 5

COMMENTARY

Small patches make critical contributions to biodiversity conservation

David Lindenmayer[a,1]

Vast areas of the earth's land surface have been altered by human activities such as clearing native vegetation for agriculture and livestock grazing, logging of natural forests, and land conversion for urban settlements (1). These activities have had profound impacts on biodiversity and on key ecosystem processes (e.g., pollination and nutrient cycling) (2). Many ecosystems have been markedly reduced in extent (often termed "habitat loss") (3, 4), with remaining areas subdivided into small, isolated remnants (typically termed "habitat fragmentation") (5). In PNAS, Wintle et al. (6) explore some perspectives associated with the conservation value of small, isolated remnants and demonstrate that they are more important for biodiversity conservation than often recognized.

A large and rapidly expanding scientific literature has accumulated on the effects of habitat loss and habitat fragmentation (e.g., refs. 5, 7, and 8). Based on concepts such as island biogeography theory (9) and species area relationships (10), a general conclusion from the myriad of studies to date has been that larger and more intact patches are better they support more species and larger populations of individual species that are more likely to persist for longer. Part of the explanation for this is that there are more niches and resources and thus more species (and more individuals of those species) in larger patches (10 12). An outcome of these general conclusions has been a focus of conservation efforts on protecting larger and more intact areas with high levels of landscape connectivity (e.g., wilderness with relatively limited human impact) (e.g., ref. 13). There is no doubt that large, intact patches are vitally important for the maintenance of some key ecological processes (13) and biodiversity conservation (14). However, Wintle et al. (6) counsel against the uncritical application of this approach. The authors demonstrate the high conservation value of small patches, particularly in heavily modified, human dominated landscapes. In their global analysis encompassing 28 countries, Wintle et al. (6) show that many species would be lost if small, isolated patches of remnant habitat were ignored and

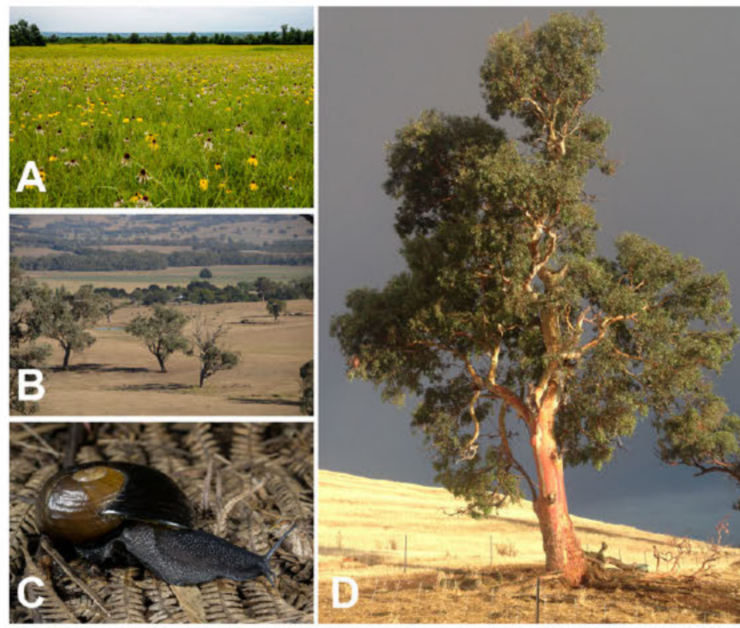

Fig. 1. Ecosystems in which only small patches remain after extensive human disturbance. (*A*) Temperate grassland ecosystem in the United States. Image courtesy of Reed Noss (photographer). (*B*) Temperate woodland in southeastern Australia. Image courtesy of David Blair (The Australian National University, Canberra, Australia). (*C*) *Paryphanta* sp., a native snail species in New Zealand, typically restricted to pig-free small patches of native vegetation. Image courtesy of Euan Brook (photographer). (*D*) Single, isolated, large old tree that has acted as a nodal point for natural regeneration of woodland vegetation in eastern Australia. Image courtesy of Mason Crane (The Australian National University, Canberra, Australia).

conservation efforts were focused solely on large, intact, and highly connected areas. The work of Wintle et al. (6) adds to the array of more spatially limited case studies that l kewise highlight the importance of small (and often relatively isolated) patches for conservation (e.g., refs. 15 19).

There are several reasons why small, isolated patches can make an important contribution to biodiversity conservation. First, in some heavily modified ecosystems, small patches are all that remains; no

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large patches exist. Species endemic to these systems must either persist within the remaining small patches or not at all. The critically endangered temperate woodlands of southeastern Australia are one of many examples of such ecosystems. In these environments, which have been 95 to 99% cleared for agriculture and livestock grazing, there are few patches larger than a few hectares in size (20) (Fig. 1). However, ensembles of temperate woodland patches, including those in poor ecological condition, can nevertheless be species rich (supporting >150 species of birds) (21). Kirkpatrick and Gilfedder (22) showed that small reserves (often in poor ecological condition) supported many rare plant species that had been eliminated from the heavily modified remainder of the landscape. There are many other ecosystems worldwide that have been extensively modified in which small remaining patches of remnant vegetation make a major contribution to the persistence of biodiversity (that likely would otherwise have been lost) in those regions [e.g., natural grasslands in the United States (4)] (Fig. 1).

A second reason why small patches can be critical for biodiversity is the absence of key processes that drive species decline elsewhere. For instance, small patches of remnant native vegetation are vital for the conservation of native land snails in New Zealand. The size of these areas precludes populations of feral pigs that can be a major predator of snails in large patches (16).

Small patches can play other crucial ecological roles beyond conserving sets of species that are extinct elsewhere in a landscape or region. For example, they can act as stepping stones that promote connectivity in otherwise highly modified environments (23). They also can be nodal points for stimulating natural regeneration of modified ecosystems, thereby contributing to vegetation restoration and broader community and biodiversity recovery (24, 25). In these and other cases, such patches may be as small as an individual tree (26).

Island biogeography theory, which has been so widely employed to promote the conservation of large patches, also may be invoked to highlight the importance of small patches. That is, under island biogeography theory, in heavily altered and highly fragmented landscapes there may be "concentration effects," with animal populations retreating from a poor quality surrounding matrix (with limited or no resources) (27) and then being reluctant to travel into the surrounding matrix, thereby becoming confined to remaining small patches (28).

The work by Wintle et al. (6) has significant implications for conservation policy and resource management. In particular, it suggests that while large intact areas can be critical for conservation, the potential value of small patches should not be ignored.

The work by Wintle et al. has significant implications for conservation policy and resource management. In particular, it suggests that while large intact areas can be critical for conservation, the potential value of small patches should not be ignored.

Such patches will often have substantial conservation value, precisely because they typically are located in highly modified environments where only limited areas of original habitat remain and the species confined to them are absent from elsewhere in the landscape. However, the management of small and isolated patches can be particularly challenging, such as protecting them from invasive species, edge effects, and clearing. Their protection also can be costly, although there are good examples of where it has been successful, especially when the public advocates for (and participates in) enhanced management (29). Investments in small and isolated patches should be underpinned by cost benefit analyses to assess trade offs involved with interventions relative to the conservation outcomes. Such analyses also may be important to assess the opportunity costs for biodiversity conservation arising from not managing other (sometimes larger) patches. A further implication of the work by Wintle et al. (6) is that some policies, like those for biodiversity offsetting, may require reform, as they currently have an inherent bias against appropriate protection of small patches (e.g., ref. 30).

Given that major global initiatives like the Aichi Biodiversity Targets aim to prevent extinctions, Wintle et al. (6) show that a focus of policy reform by governments must include not only the protection of large, intact areas but also small, isolated patches within highly modified environments. In addition, despite the massive and rapidly increasing literature on landscape change and habitat fragmentation, it is remarkable how rarely the contribution to landscape and regional species pools from taxa inhabiting small patches has been quantified (but see ref. 15). More empirical work is urgently needed to underpin the case for their conservation.

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ATTACHMENT 6

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Understanding the importance of small patches of habitat for conservation

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Summary

1. Conservation activities in fragmented landscapes have largely focused on keeping remaining large patches intact, often disregarding the increasingly important role of smaller patches in the conservation of remaining vegetation. As habitat loss proceeds in fragmented landscapes, there is an increasing need to measure the relative contribution of all patches (large and small) to overall ecosystem persistence, in a way that helps deliver effective conservation strategies aimed at preventing the death of ecosystems by a thousand cuts.

2. Using Australian vegetation communities as a case study, we calculated the historical change in the contribution of patches below different sized thresholds to overall extent. We introduced a new patch assessment metric based on the Gini coefficient that indicates how unequal the distribution of patch sizes is relative to historical distributions.

3. At least 22% of major vegetation communities in Australia have $>50\%$ of their remaining extent in patches <1000 ha. Loss does not always match fragmentation status: though some vegetation communities are exposed to the double jeopardy of high loss and high fragmentation, others are far more affected by fragmentation than loss of extent.

4. For some communities, actions focused on protecting large patches are critical but for many others, protecting and managing small patches is crucial for community persistence.

5. *Synthesis and applications*. Arbitrary patch size thresholds for permitting native vegetation clearing are dangerous for ecosystems whose distribution is now restricted to small patches. We recommend that clearing thresholds be scaled to reflect the fact that some ecosystems are more dominated by small patches than others. With a renewed focus on formally assessing the threat status of ecosystems as well as species, ecosystem accounts such as those demonstrated in this study are the first step to reliably assessing vulnerability. Measures of ecosystem vulnerability that only consider the extent of vegetation loss and not the size of remaining patches are likely to be ineffective for impact assessment, conservation planning and preventing ecosystem loss.

Key-words: Australia, environmental accounts, fragmentation, Gini Index, habitat area, IUCN Red List of Ecosystems, land-clearing policy, National Vegetation Information System, patch size, threatening processes

Introduction

Despite significant attempts to protect ecosystems from large scale clearance via conservation actions such as protected areas (Watson *et al.* 2014) and compensation schemes (Grieg Gran 2006; Combes Motel, Pirard & Combes 2009), more than 80% of the terrestrial world has been modified by human activities (Sanderson *et al.* 2002). At the global scale, almost all ecosystems are declining in total extent, as well as becoming increasingly fragmented (Saunders, Hobbs & Margules 1991; Fischer

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& Lindenmayer 2007; Laurance *et al.* 2011). Consequently, small patches are now not only a common feature in many landscapes, but also represent an increasingly large component of remaining habitat in many ecosystems.

The last two decades have seen a large body of ecological theory and field research highlighting the role of large patches of vegetation in enabling habitat dependent species persistence (Andren 1994; Bender, Contreras & Fahrig 1998; Fischer *et al.* 2009). The importance of maintaining large patches is repeatedly emphasized in theory (MacArthur & Wilson 1967) and practice (Ferraz *et al.* 2007; Mortelliti *et al.* 2014). Species area relationships (Rosenzweig 1995), patch size population density relationships (Connor, Courtney & Yoder 2000) and assessments of the impact of edge effects on patch size (Beier, Van Drielen & Kankam 2002; Watson, Whittaker & Dawson 2004) all support large contiguous habitat blocks. A consequence of this wealth of evidence has been that conservation oriented actions in fragmented landscapes (e.g. vegetation legislation, offset design and best practice agricultural land management) have been almost ubiquitously framed around keeping remaining large patches intact, and ensuring connectivity between large patches is created or maintained. These actions are no doubt important for maintaining biodiversity, but a singular focus on keeping large patches intact and well connected can mean that smaller patches are overlooked in landscape conservation (but see Ovaskainen 2002). Simply by maintaining geographic extent, small patches contribute to short and long term species persistence, but are often the most vulnerable to land clearing. For instance, landholders in many countries (e.g. Brazil, Canada, Australia and New Zealand) are allowed to routinely clear small (<1 ha) vegetation patches without permits or vegetation assessments being conducted (Stobbe, Cotteleer & Cornelis Van Kooten 2009; Stickler *et al.* 2013; Taylor 2013).

As the erosion and fragmentation of vegetated landscapes continues (Hansen *et al.* 2013), a better understanding of the relative roles of smaller patches in conservation strategies is needed. Vulnerability of a given ecosystem is traditionally assessed via loss of extent (Nicholson, Keith & Wilcove 2009; Keith *et al.* 2013), usually by measuring the total proportion of that community that has been removed (e.g. global forest assessments; FAO 2012; Keith *et al.* 2013). There are currently no widely accepted or effective solutions to account for the influence of the spatial arrangement of available habitat (such as the relative contribution of small or large patches) on ecosystem persistence and vulnerability (Smith *et al.* 2009; Wang & Cumming 2011). Assessing the importance of variable patch sizes to ecosystem persistence could provide planners with guidance on the size and number of small patches that should be managed. This might assist with protecting minimum habitat targets for species of conservation concern (Goldingay & Possingham 1995), or assessing the amount of clearing of small patches that an ecological community might tolerate before risk of ecosystem collapse due to accumulated loss of extent. Reliable metrics accounting for both loss of extent and patch contribution are needed to understand the pace of habitat loss and landscape beta diversity change, assess ecosystem vulnerability and make decisions about where and if protection or vegetation clearing should be permitted (Villard & Metzger 2014). Without considering these metrics, we risk continuous erosion of small patches and the slow, inevitable decline of vegetation communities and the species dependent on them for their persistence: a death by a thousand cuts.

Here, we provide two new measures of vegetation change that consider the relative size of remaining vegetation patches. Using data on vegetation clearing in Australia, we evaluate the amount of fragmentation that has occurred to vegetation communities by accounting for (i) the importance of small patches and (ii) patch inequality, which are comparable between communities and take into account historical baselines. We compare these two patch related measures with a traditional measurement of vegetation community loss of extent. In doing so, we assess the vulnerability of vegetation communities to both total loss and fragmentation and as such provide a case study of the contribution of small patches to conservation outcomes.

Materials and methods

CASE STUDY

Our case study is the megadiverse continent of Australia (Mittermeier, Mittermeier & Gil 1997), chosen because (i) data are available on the distribution and size of vegetation patches both today and historically; and (ii) widespread recent (within the past 200 years) vegetation clearing has led to serious biodiversity issues across many parts of the continent (Lindenmayer 2007; Kingsford *et al.* 2009). We defined vegetation communities according to the Australian Government's National Vegetation Information System (NVIS 4.1, Australian Government Department of Sustainability, Environment, Water, Population and Communities). This unique raster data set summarizes Australia's present (extant) native vegetation, classified into 85 Major Vegetation Subgroups (NVIS MVS 4.1) at 100 × 100 m (1 ha) resolution, with a comparable estimated pre 1750 (pre European, pre clearing) data set also available. We excluded all non vegetation and cleared vegetation types (e.g. freshwater, seas), resulting in a final list of 75 vegetation communities.

RATE OF CLEARING OF NATIVE VEGETATION

We estimated the relative change in total original extent that each vegetation community has undergone since European settlement of Australia (from now on termed 'pre 1750'). We then derived the total area (in square kilometres) covered by each classified NVIS MVS from the maps of pre 1750 and extant vegetation and calculated the percentage change between these two values for each community.

ACCOUNTING FOR SMALL PATCH CONTRIBUTIONS TO REMAINING EXTENT

To determine the number and size of patches in each vegetation community, we converted the raster layers of pre 1750 and extant NVIS MVSs to individual polygons and calculated the area of each polygon. For each pre 1750 and extant vegetation community, we ranked patches in ascending order of size, calculated the cumulative area for each community based on patch rank and derived the proportional cumulative area of every patch (for supporting code see Appendix S2 in Supporting Information). Patches were defined as a contiguous polygon not directly connected to any other polygon of the same vegetation type.

We explored the ability of two simple approaches to account for small patch contribution to remnant vegetation, in relation to a historical baseline. First, we set patch size thresholds across all vegetation communities, below which the patch is considered small and therefore vulnerable to clearing. Fixed thresholds are easy to explain, quickly reduce uncertainty and are therefore commonly used in decision making (Huggett 2005; Nicholson, Keith & Wilcove 2009), such as for permissible deforestation on private land (McAlpine, Fensham & Temple Smith 2002). Our first metric describes the relative change between the pre 1750 and current contribution (C) of small patches to the total extent of a given vegetation community. To calculate this, we used the following formula:

$$C(a) \quad P_e(a) \quad P_0(a),$$

where P_e is a value between zero and one representing the proportion of the extant vegetation community extent made up of patches that are smaller than the threshold patch area (a), and P_0 is a value between zero and one representing the proportion of the original (baseline) vegetation community extent made up of patches that are smaller than a. A value of zero represents no change, whereas a value of 1 indicates that all patches are now smaller than the threshold. We calculated the proportion of the original and remaining extent of each vegetation community that consisted of patches smaller than thresholds of 1, 2, 5, 10, 20, 50, 100, 1000, 5000, 10 000 and 100 000 ha. We report results for a threshold of 5000 ha in the main text. We do not know the minimum critical area of habitat required by most species in Australia, but between 1000 and 5000 ha of effective habitat is considered to be a reasonable area for maintaining species genetic diversity in Australia (Lancaster *et al.* 2011) as well as preventing mammal population extinctions both in Australia (Goldingay & Possingham 1995; Jackson 1999; Nicholson *et al.* 2006) and in other parts of the world (Ferraz *et al.* 2007; Mortelliti *et al.* 2014).

Because thresholds are arbitrary (Maron *et al.* 2012), we compared our patch contribution measure based on thresholds with a measure based on patch inequality that accounts for all patch sizes and their relative contribution to the overall extent of a vegetation community. The Gini coefficient is the most widely known and used measure of inequality in economics (Allison 1978), and it measures the difference between a perfectly equitable distribution and the actual distribution of a resource. Recently, the Gini coefficient was proposed as a way for establishing the level of equality of protection across the world's terrestrial ecoregions within 83 countries (Barr *et al.* 2011). Because it is bound between zero (most even) and one (least even), it is easy to interpret and communicate to planners and policymakers. We investigated whether the Gini coefficient could be adapted to evaluate landscape spatial configuration of remnants, by measuring equity in the distribution of patch sizes within any given vegetation community.

We calculated a Gini coefficient for each extant and 1750 vegetation community using Brown's (1994) formula:

$$G \quad 1 \quad \sum_{i \quad 0}^{n-1} (Y_{i+1} + Y_i)(X_{i+1} \quad X_i),$$

where X_i is the cumulative proportion of n remnants in the vegetation community, for $i \quad 1,\ldots, n$, and Y_i is the cumulative proportion of the current area of n remnants in the vegetation community, for $i \quad 1,\ldots, n$. We then derived the change in the Gini coefficient ($\triangle G$) between current and baseline conditions:

$$\Delta G \quad G_e \quad G_0,$$

where G_e is the Gini coefficient for the current (extant) vegetation community, and G_0 is the Gini coefficient for the historical (pre 1750) vegetation community. This metric takes a value between 1 and 1. A negative value represents communities becoming more equal in patch size distribution; a positive value represents less equality in patch size distribution.

All statistical analyses were performed in R version 3.1.1 (R Core Team 2014), and all spatial analyses were conducted in ESRI ARC GIS version 10.0.

Results

LOSS OF VEGETATION COMMUNITY EXTENT

Many communities have been heavily cleared (Tables 1 and 2), but vegetation clearing has not impacted all communities equally (Fig. 1a), nor is it occurring at equal rates across the continent (Fig. 2a). In Australia, 24 broad vegetation communities (32% of the 75 evaluated) have lost at least 20% of their original extent, and seven communities (9%) have lost >40% of their original extent. Many of those most heavily cleared occur in the agriculturally productive coastal regions of Australia (Fig. 2a). The three most heavily cleared communities (mallee with a tussock grass understorey, Brigalow and temperate tussock grasslands), together previously covered more than 170 000 km^2 of Australia, and each has <20% of their original extent remaining (Table 1). In comparison, 19 (25%) vegetation communities have lost a very small (<2%) proportion of their original extent (Fig. 1a).

Vegetation communities were not distributed equally in their original areal extent (Table 1). Original vegetation cover ranged over 4·6 orders of magnitude across vegetation communities (Fig. 3a). There is no consistent relationship between original extent and proportional loss (linear regression: R^2 0·02; F 1·38, d.f. 1,73; P 0·24). For example, *Banksia* woodlands originally covering approximately 7300 km^2 of Australia have lost almost 50% of their extent. In contrast, cool temperate rainforest originally covered a similar area (8175 km^2) and has lost <5% of its extent.

Table 1. Results of metrics per Australian vegetation community (NVIS major vegetation groups), showing top 20 for loss of extent, change in proportion of patches smaller than 5000 ha and Gini metric (for NVIS codes and additional patch size thresholds see Supporting information)

Vegetation community	pre 1750 area (km^2)	% Loss of extent	Rank loss of extent	Number of pre 1750 patches	% Change in number of patches	Proportion change in number of patches <5000 ha *C* (5000)	Rank thresh old	Gini metric ΔG	Rank Gini
Mallee with a tussock grass understorey	60 484	97 3	1	16 309	1 3	0 86	1	0 161	1
Brigalow forests and woodlands	96 493	86 9	2	48 618	379 7	0 66	3	0 061	4
Temperate tussock grasslands	16 594	81 7	3	38 494	150 2	0 68	2	0 159	2
Open mallee woodlands and sparse mallee shrublands with a tussock grass understorey	1904	70 7	4	7531	0 7	0 08	19	0 098	3
Banksia woodlands	7327	49 5	5	8361	302 7	0 20	5	0 028	10
Eucalyptus woodlands with a tussock grass understorey	725 124	46 8	6	583 880	88 6	0 14	8	0 018	18
Casuarina and Allocasuarina forests and woodlands	28 232	44 3	7	70 911	12 7	0 09	14	0 025	14
Low closed forest or tall closed shrublands (including Acacia, Melaleuca and Banksia)	28 900	39 2	8	73 603	5 7	0 06	24	0 027	11
Tropical or subtropical rainforest	21 037	37 8	9	61 373	13 5	0 17	6	0 037	7
Open mallee woodlands and sparse mallee shrublands with a dense shrubby understorey	7827	37 3	10	7997	12 6	0 13	10	0 021	16
Blue grass and tall bunch grass tussock grasslands	28 988	36 8	11	14 753	45 9	0 15	7	0	45
Eucalyptus woodlands with ferns, herbs, sedges, rushes or wet tussock grassland	16 430	35 5	12	84 922	52 1	0 08	17	0 048	5
Dry rainforest or vine thickets	15 720	35 4	13	33 191	10 5	0 02	34	0 03	9
Other shrublands	99 063	32 2	14	78 168	80 2	0 11	13	0 011	22
Eucalyptus woodlands with a shrubby understorey	390 075	30 3	15	298 578	71 1	0 08	16	0 011	23
Mallee with an open shrubby understorey	57 075	27 3	16	68 323	48 9	0 05	27	0 007	30
Eucalyptus open woodlands with a grassy understorey	193 898	26 5	17	168 772	42 4	0 05	28	0 005	33
Open mallee woodlands and sparse mallee shrublands with an open shrubby understorey	4230	25 1	18	3362	95 8	0 06	21	0 012	72
Saline or brackish sedgelands or grasslands	1259	24 9	19	7970	2 1	0 12	12	0 031	8
Other Acacia forests and woodlands	111 049	23 3	20	70 660	14 0	0 06	23	0 009	27
Eucalyptus (+/ tall) open forest with a dense broad leaved and/or tree fern understorey (wet sclerophyll)	28 539	19 9	24	228 279	5 6	0 22	4	0 039	6

Table 1. (Continued)

Vegetation community	pre 1750 area (km^2)	% Loss of extent	Rank loss of extent	Number of pre 1750 patches	% Change in number of patches	Proportion change in number of patches <5000 ha C (5000)	Rank thresh old	Gini metric ΔG	Rank Gini
Eucalyptus tall open forests and open forests with ferns, herbs, sedges, rushes or wet tussock grasses	43 209	19 3	25	188 514	20 1	0 14	9	0 026	12
Eucalyptus open forests with a shrubby understorey	117 521	21 6	23	417 050	19 1	0 12	11	0 026	13
Tropical mixed species forests and woodlands	10 161	12 2	74	11 197	126 1	0 08	15	0 013	20
Eucalyptus open forests with a grassy understorey	177 016	17 8	27	456 194	10 1	0 08	18	0 016	19
Mallee with a dense shrubby understorey	91 555	22 6	21	99 032	53 3	0 07	20	0 011	24
Eucalyptus tall open forest with a fine leaved shrubby understorey	9220	12 6	31	138 724	2 2	0 05	29	0 022	15
Casuarina and Allocasuarina open woodlands with a tussock grass understorey	4923	1 1	58	1360	29 6	0	73	0 021	17

Table 2. Results of paired *t* tests comparing current and historical (pre 1750) mean extent and mean number of patches of 75 broad veg etation communities in Australia. For specific results of statistical differences in patch size distributions for each vegetation community, Table S5 provides results of Mann Whitney Wilcoxon tests

Community characteristic	Current mean (±SE)	Historical mean (±SE)	*t* Statistic	*P*	d.f.
Extent (km^2)	88 462 ± 20 275	102 132 ± 21 881	2 783	0 003	74
Number of patches	62 057 ± 12 040	49 720 ± 9044	2 955	0 002	74

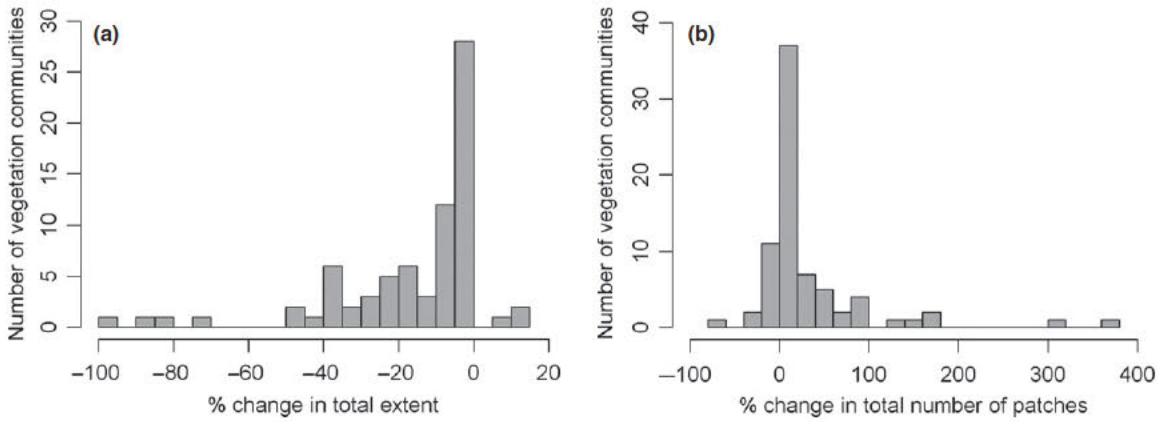

Fig. 1. Frequency histogram of the number of vegetation communities exhibiting a given (a) percentage change in extent and (b) change in number of patches. Communities at the far left have (a) lost the majority of their original extent or (b) lost patches. Communities at the far right (above 0) have (a) gained in extent, replacing other communities due to land management practices, or (b) increased their patchiness.

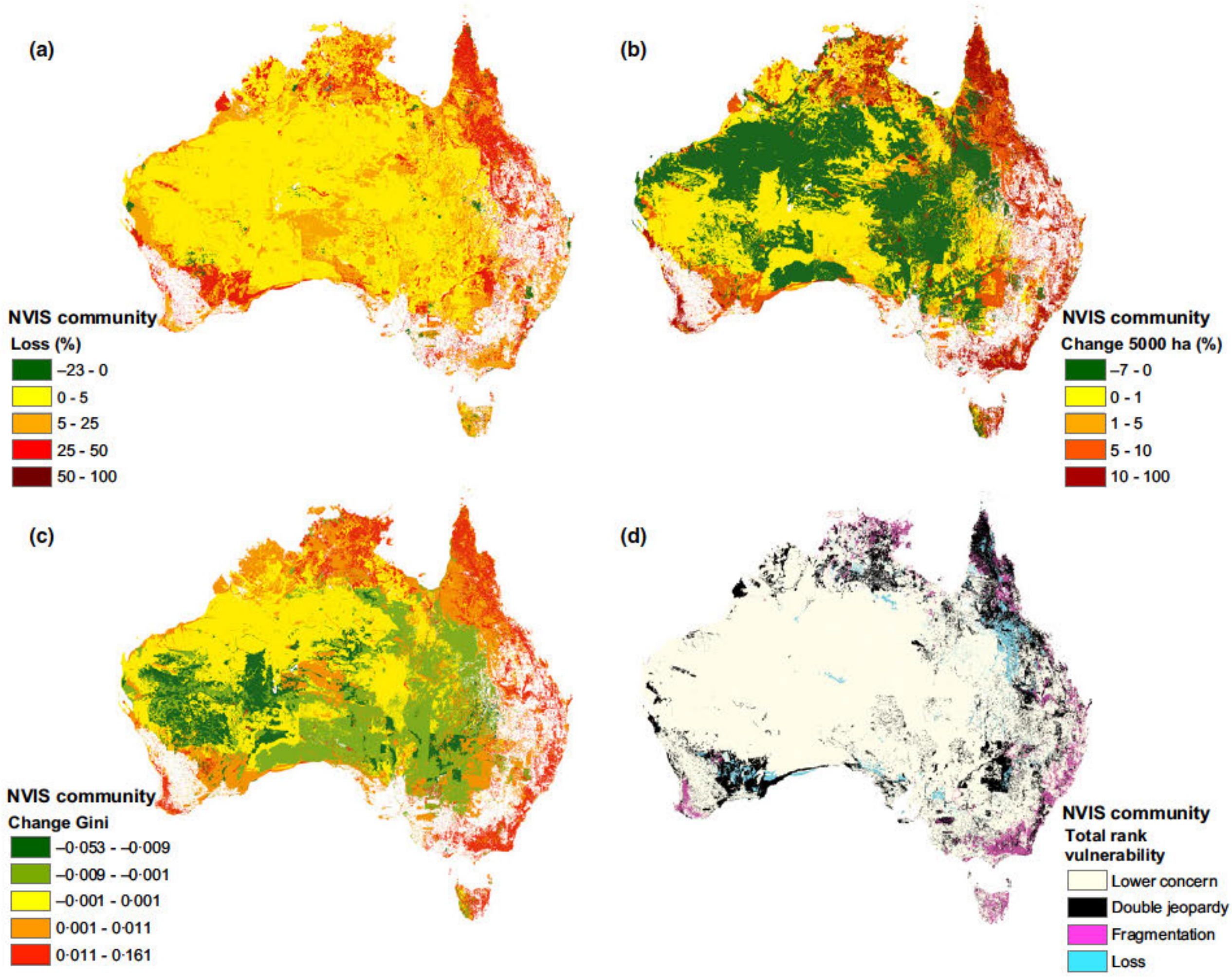

Fig. 2. Map of Australia showing each vegetation community colour coded by (a) total loss of extent, (b) fragmentation measure (change in proportion made up of <5000 ha patches) and (c) Gini metric (change in coefficient). Red areas represent those vegetation communities with high (negative) change for the worst, green represents a positive change (i.e. gain in extent, less extent below patch size threshold) and yellow no (or very little) change. In (d), vegetation communities experiencing double jeopardy (top ranked for increasing contribution of small patches and loss) are shown in black, with light shades of yellow indicating lower concern (affected relatively less by loss or fragmentation compared with other communities and not ranked in top 25 for either), pink representing top ranked for more impact by fragmentation (10 NVIS types) and blue representing top ranked for more impact by vegetation loss (five NVIS types). Vegetation communities are colour coded by the total change (i.e. a single value per community).

SMALL PATCH CONTRIBUTIONS TO REMAINING EXTENT

There are more individual patches per community today on average than historically (*t* test $P < 0{\cdot}01$, Table 2). A linear regression revealed that 22% of the variation in the increase in number of patches could be explained by loss of extent (F 21·07, d.f. 1,73; $P < 0{\cdot}01$). The number of patches per community has increased since clearing began for 81% (61) of the communities despite a mean loss of 18·8% (±2·9 SE) of the extent of these 61 communities (Fig. 1b, see also Appendix S1). For instance, Brigalow formerly extended across 96 492 km^2 distributed amongst 10 136 patches. Today, this has been reduced by 87% to 12 665 km^2 distributed amongst 48 618 patches: a fourfold increase in the original number of patches despite the enormous overall decline in extent (Table 1). Conversely, for the 14 communities in which the number of patches has declined (Fig. 1b), the overall change in extent was small (mean ± S.E.: 2·8 ± 1·9%).

The importance of small patches in representing communities varied historically and today (Fig. 3b). Vegetation communities generally had less small patches and more large patches contributing to their extent pre 1750 (Table 2, Fig. 4a,b). Exceptions include cool temperate rainforest and boulders communities that were naturally patchy due to their position on the tops of mountains (Fig. 4a,b). The contribution of patches <5000 ha has increased in all parts of Australia (Fig. 2b; red, orange and yellow areas), with patches <5000 ha now comprising an equal or greater proportion of almost all the vegetation communities (Fig. 3b; Table S1). This change in the

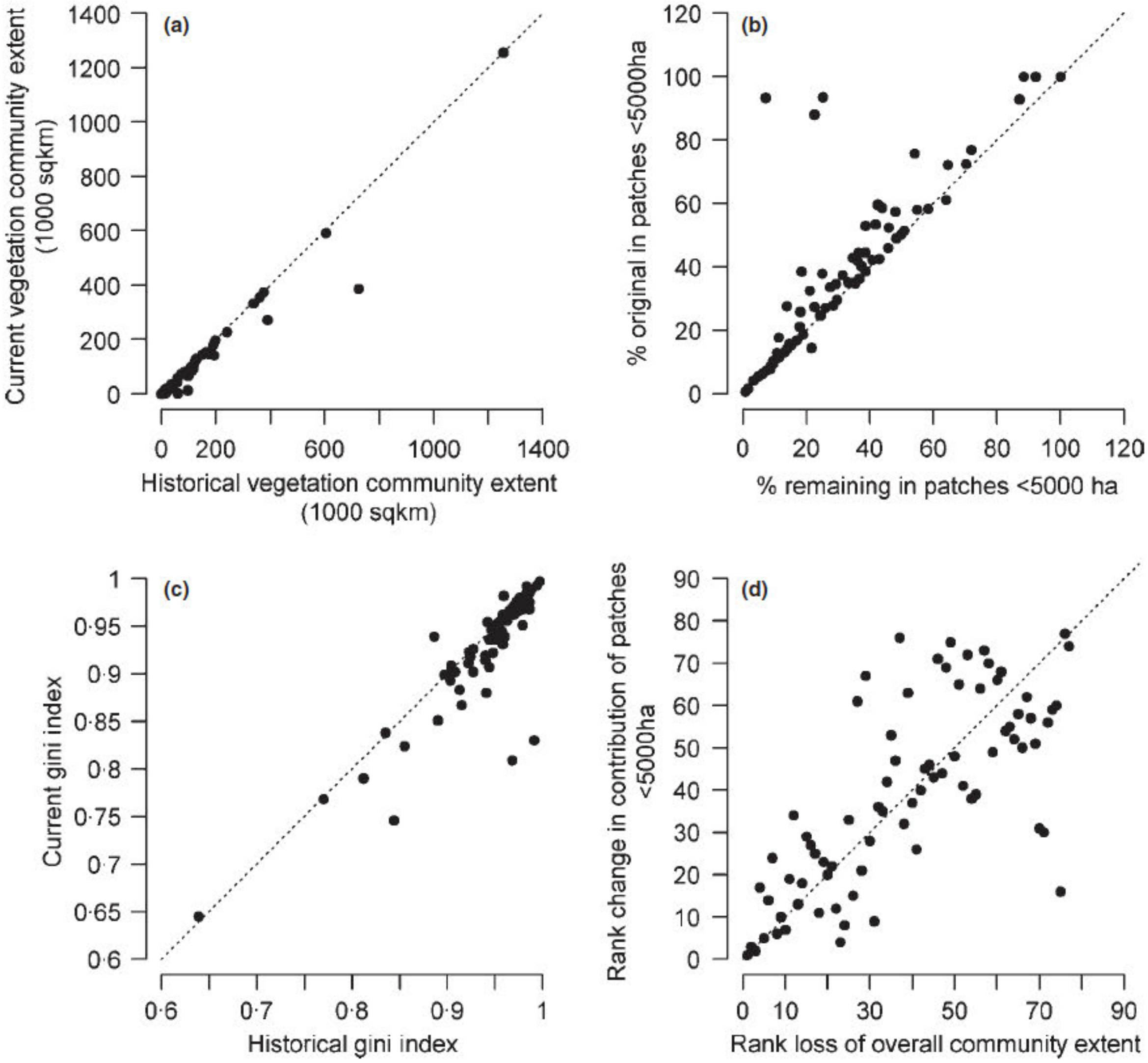

Fig. 3. Comparison of vegetation community loss measure and fragmentation measures for (a) total community extent, (b) small patch contribution (<5000 ha), (c) evenness (Gini Index) and (d) change in ranks of communities by remaining patches smaller than 5000 ha versus loss of extent. The dotted lines represent parity (no change between historical and current conditions). In (d), communities below the dotted line are ranked relatively higher for small patch contribution (indicating they are more influenced by fragmentation than loss of extent), communities above the dotted line are ranked higher for loss of extent (indicating they are more vulnerable to loss than frag mentation), and communities close to the dotted line are either influenced by neither relative to other communities (top right corner) or affected equally by both (bottom left corner).

contribution of small patches is positively related to loss of extent (linear regression: R^2 0·68; F 163·22, d.f. 1,73; $P < 0·01$).

Today, almost all of the remaining extent (95%) of ten communities is represented in patches <10 000 ha (Fig. 4d). This includes communities such as Brigalow (Fig. 4a), for which <35% of its extent are in patches below this 10 000 ha threshold (Fig. 4b). More than a third of the remaining extent of 35% (27) of communities is made up of patches smaller than 1000 ha (10 km^2). For 13 of these (18% of all communities), the proportion comprised of patches <1000 ha rises to at least 50% (Fig. 4d) originally, only eight communities (10%) had half of their extent represented by patches smaller than 1000 ha (Fig. 4c, Table S3). Four communities have at least a quarter of their remaining distribution in patches smaller than 10 ha (open mallee woodlands, *Leptosper mum* forests and woodlands, *Eucalyptus* tall open forest with fine leaved shrubby understorey, and Boulders or alpine fjaeldmarks) despite three of these (*Eucalyptus* forest, *Leptospermum* forests and Boulders) being natu rally patchy, this proportion has increased for all commu nities.

Comparing Gini coefficients for each vegetation com munity between 1750 and today (Fig. 3c) showed that 43% (33) have become more equitably distributed in terms of patch sizes (a declining Gini coefficient), 12% (9) have become less equitably distributed (an increasing Gini

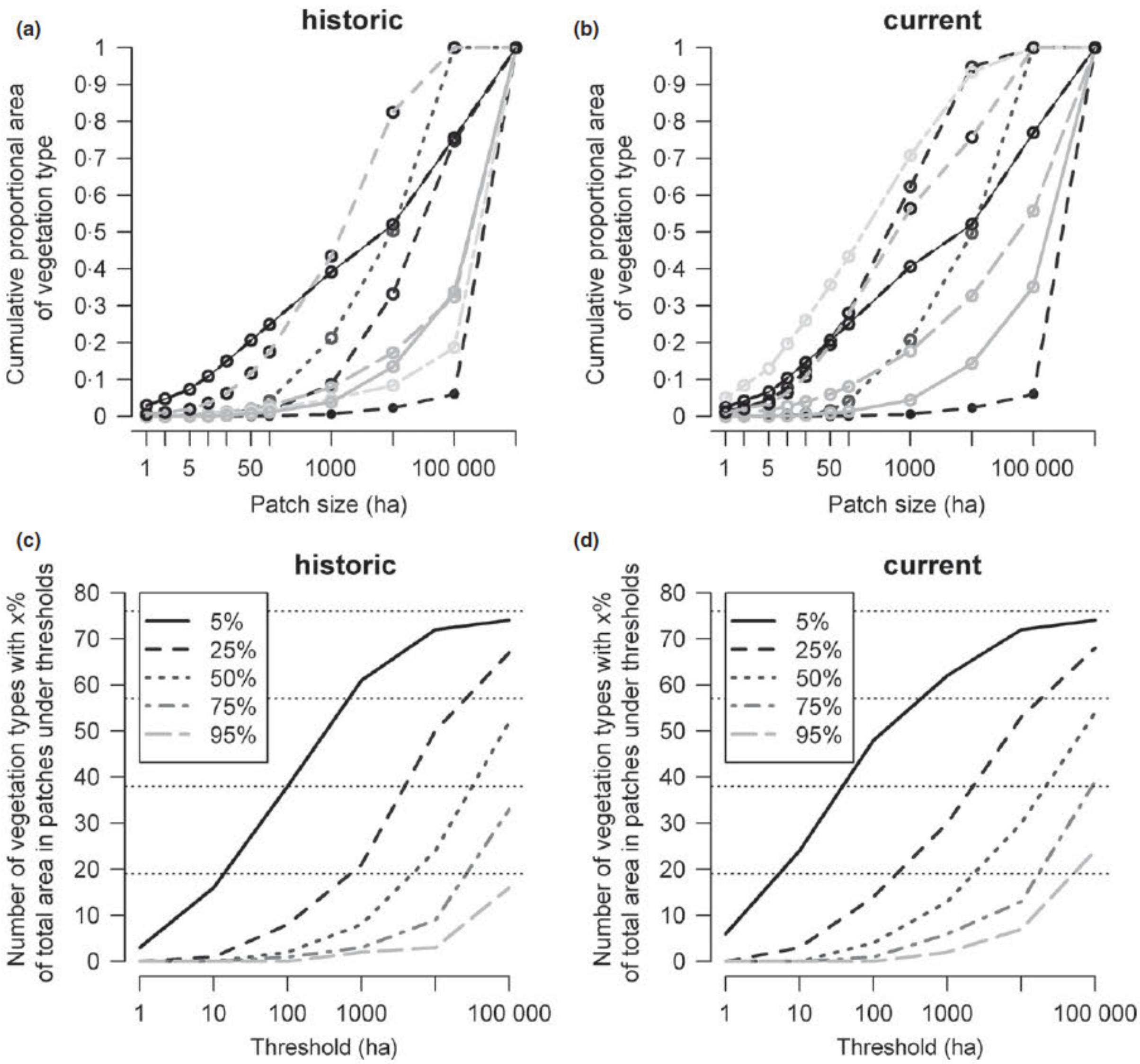

Fig. 4. Cumulative area curves relative to patch size (hectares, ha) overlaid for five communities for (a) extant patches, (b) original 1750s' distribution of patches; and results for all current communities, showing how many communities had a given percentage of their (c) historical and (d) remaining extent in patches under a particular patch size threshold.

coefficient), and 45% (35) have shown <0·5% change in equitability (Table 1 and Tables S1 and S5). Communities more equitably distributed with regard to patch sizes (i.e. with a decline in the Gini coefficient) are generally a result of most of the large patches being broken up into many small patches, as these communities had a greater contri bution of small patches today than historically (linear regression: R^2 0·72; $P < 0{\cdot}01$; Table 1). Communities with less equitably distributed patch sizes are generally a result of small patches becoming smaller, whilst the com munity still maintains some big patches (Table S6).

Neither the Gini Index nor the patch contribution mea sure is sensitive to all forms of landscape change. In some rare cases, fragmentation occurred (with resulting increase in the contribution of small patches) but a comparison of Gini Indices between 1750 and today shows no change, when all patch sizes were fragmented equally (e.g. mulga open woodlands; Table S6). In other cases, the Gini Index shows sensitivity to change in patch distributions whilst the patch contribution measure remains constant over time, due to processes such as edge removal from all patches (e.g. dry rainforest or vine thickets; Table S6).

RELATIONSHIP BETWEEN LOSS AND PATCH CONTRIBUTION

Loss of extent and fragmentation have clearly not occurred evenly across all vegetation communities (Table 1 and Table S6). By ranking vegetation communi ties by overall loss of extent and by the change in the con tribution of small patches, we were able to discover which communities did not conform to general relationships of increasing fragmentation with increasing loss of extent (Figs 2d and 3d). Some communities were impacted very little by either fragmentation or loss (e.g. hummock grass lands, saltbush and bluebush shrublands) and mostly occur in the arid central regions of Australia (Fig. 2d). A number of vegetation communities were subject to double jeopardy because they are being highly impacted by both loss of extent and fragmentation (e.g. mallee with a tus sock grass understorey, Brigalow forests and woodlands, and *Banksia* woodlands; Fig. 2d), with associated increase in patch equity generally due to an increase in the overall number of small patches and loss due to fragmentation of large patches (Table 1, Fig. 4a,b). Relative to other vege tation communities, at least 17 vegetation communities were more impacted by fragmentation but less by loss (e.g. *Eucalyptus* open forest with a dense broad leaved and/or tree fern understorey, mangroves), and 18 commu nities were more impacted by loss than fragmentation (e.g. dry rainforest or vine thickets, mallee with an open shrubby understorey; Fig. 3d; see Appendix S3).

Discussion

Fragmentation is now widespread across ecosystem types and regions. Increased clearing of vegetation communities in Australia (Fig. 3a) has led to many more individual patches in the landscape and small patches taking on increased importance (Table 2, Figs 3b and 4d). Despite increasing research focus on evaluating risks to ecosys tems (Nicholson, Keith & Wilcove 2009; Keith *et al.* 2013), the different forms of habitat loss and fragmenta tion have not yet been assessed in a way that helps deliver applied conservation outcomes. We demonstrate new ways to assess the overall contribution of conserving patches of different sizes to the persistence of a vegetation community, as small patches may be crucial to species survival and community resilience (Matthews, Cottee Jones & Whittaker 2015). In doing so, we show the importance of better evaluating the vulnerability of all vegetation communities to threatening processes, regard less of their size and extent of loss.

Many vegetation communities in Australia now occur disproportionately in small patches (Fig. 4d); at least 13 (17%) major vegetation communities in Australia mainly comprise (>50% of their current extent) patches under 1000 ha (10 km^2; Fig. 4d). This figure doubles if we con sider patches smaller than 5000 ha (50 km^2). However, in Australia (as in many parts of the world), small scale veg etation clearing continues at pace with few checks (Taylor 2013), leading to the gradual erosion of remaining small patches. In Australia, the only legislative trigger to pre vent clearing of small patches is the presence of a species or community formally listed under the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*. By the time a community is EPBC listed, many of the last remaining small patches of that vegetation may have been cleared. For example, 10 vegetation communi ties currently have at least 30% of their remaining extent in patches smaller than 100 ha (1 km^2), an area that under some recent land clearing legislation changes is per missible for clearing, sometimes without a permit if the community occurs on prime agricultural land (Taylor 2013). Because six of these communities have not yet suf fered more than 30% loss of extent and therefore cannot be legislatively protected, legalized land clearing can occur in such a way that it will cause significant cumulative impact to warrant listing as vulnerable under IUCN Red List guidelines (Keith *et al.* 2013). To adequately identify ecosystems at risk of collapse, there is a need to move away from relying solely on the amount or rates of loss and assess the overall contribution of all vegetation patches to the ecosystem's long term viability. By quanti fying the reliance of vegetation communities on a variety of patch sizes, we show that it is possible to explicitly con sider the influence of fragmentation, and the impact of clearing patches of a given size, for a given community. As a result, environmental impact assessments and subse quent development and offset decisions could more easily take into account fragmentation implications for affected communities, and trade offs within and between different sized vegetation communities can be considered.

The approach demonstrated here could be used to set more realistic thresholds of permissible vegetation clear ing, which reflect the relative vulnerability of each com munity to the threat of ongoing clearance of small patches. Setting an arbitrary patch size clearance allow ance where no penalties occur for clearance of small patches, as currently seems to be the case with some pol icy instruments (Maron *et al.* 2012), seals the eventual fate of all patches below that threshold. This could be especially dangerous in landscapes with low habitat nest edness, in which multiple complementary small and large patches are required to maintain species persistence (Mat thews, Cottee Jones & Whittaker 2015). Similar to setting conservation planning targets for biodiversity protection (Smith, Goodman & Matthews 2006), it might be better to equalize the proportion of remaining vegetation patches that we are prepared to lose rather than settle on a fixed area. For example, if conservationists wanted to ensure <25% of remaining vegetation is cleared whilst still allowing small patches (e.g. on prime agricultural land) to be cleared, the definition of a 'small' patch contributing to the permissible 25% would be highly variable (Fig. 4d). Sensitivity analyses showed that the patch size threshold below which 25% of the total extent of Australian vegeta tion communities occurred varied from 0·03 to 116 970 km^2 (Appendix S1). Permissible patch size clear ing thresholds related to the percentile contribution of small patches to overall extent would allow clearance regimes to be tailored to each ecosystem, with an aim to prevent death by a thousand cuts. We believe these tai lored thresholds could equally apply to current IUCN Red List of Ecosystems assessments (Rodriguez *et al.* 2011; Keith *et al.* 2013), especially around those criteria that assess reduction in geographic range (A), environ mental degradation based on an abiotic variable (C) and quantitative analysis that estimates the probability of ecosystem collapse (E). None of these criteria fully con sider the conservation implications of fragmentation and small patch size, which will have implications for habitat loss in the future.

Our new fragmentation measures are a first attempt in understanding and quantifying overall community vulner ability. We describe only how quantifying current patch contribution to overall extent in relation to original con tribution can facilitate better understanding of ecosystem vulnerability. Although the proposed Gini metric enables a more complete understanding of the evolution of changes in the spatial structure of ecosystems, it is diffi cult to interpret if used alone without accompanying mea sures of fragmentation. For example, the absolute value of the Gini Index might be similar for two landscapes experiencing similar variation in patch inequality, but these landscapes might differ in the contribution of small patches (Table S6) as well as the extent, connectivity and spatial arrangement of habitat patches. Because we do not include data on the effect of habitat loss and fragmen tation on species persistence, we suggest that our metrics be viewed as complementary to each other and to other existing fragmentation measures (Wang, Blanchet & Koper 2014; see Appendix S2 for an assessment of how measures compare). To fully describe the vulnerability of ecosystems to loss and fragmentation, we argue that it is necessary to apply both our measures and complementary assessments (e.g. connectivity, edge or perforation mea sures), in addition to understanding the biological mean ing of these measures for species within those ecosystems (Riitters *et al.* 2000; Table S6).

Aside from general species area hypotheses (Simberloff 1992), it is difficult to predict how most kinds of fragmen tation might contribute to ecosystem vulnerability (Debin ski & Holt 2000; Fahrig 2003). By accounting for the distribution of patches in the historical and the current study landscape, respectively, our measures improve on most existing fragmentation metrics that do not distin guish between natural and anthropogenic fragmentation. Although fragmentation clearly results in direct loss of some species and indirect loss of others due to vegetation removal or alteration, many species perform well in small isolated patches (Ryall & Fahrig 2006; Bowen *et al.* 2009). Many ecosystems naturally occur in small patches (Appendix S1), and therefore, the species within them have higher resilience to fragmentation than other com munities. This variation in the sensitivity of biota to the species area relationship across ecosystems and across taxa (Martensen, Pimentel & Metzger 2008) means that the patch size threshold cut offs used to compare histori cal and current proportional contribution to remaining extent in this study (Fig. 4) will not necessarily generalize to other parts of the world. The appropriate scale at which to measure patch size vulnerability is the one at which the ecological response matches the landscape structure (Jackson & Fahrig 2012). Ideally, to better understand the importance of small patches, conceptual models of the interactions between vegetation community patch sizes, productivity and the requirements of the spe cies within them should be developed (Villard & Metzger 2014). Because this varies across species and ecosystems, we suggest exploring a range of alternative threshold min imum patch areas, much like fish size restrictions are explored for sustaining recreational fisheries (Post *et al.* 2003).

For simplicity, we assumed that vegetation clearance was the only action affecting fragmentation and resulting patch size, and that patches were not connected if sepa rated by more than 100 m (the resolution of the data set). Future studies could incorporate additional threatening processes such as infrastructure, which result in partial clearing and require knowledge of the impact on patch connectivity and persistence. Our approach does not attempt to quantify environmental degradation due to worsening vegetation condition, as condition data at a national level are rarely available, and detailed instruc tions for assessing this component (e.g. for the Red List of Ecosystems) have been prepared elsewhere (Keith *et al.* 2013). We used the Australian NVIS 1750 map to esti mate historical (i.e. pre clearing) conditions. This map has higher accuracy than some parts of the world because Australia has a relatively recent history of clearing. For countries or regions where detailed historical maps are not available, methods are now being developed based on predictive distribution modelling of historical ecosystem patterns (Ewers *et al.* 2013), geophysical mapping (Ander son & Ferree 2010; Sanderson, Segan & Watson 2015), or using genetics to determine historical biodiversity patterns in different areas (Boessenkool *et al.* 2014). Either way, making an assessment now is critical, as this can be updated over time in environmental accounts that record which ecosystems are worsening or improving.

The measures demonstrated in this study allow planners and researchers to assess how dependent ecosystems are on patches of different sizes. By exploring a range of patch size thresholds, planners and decision makers can evaluate the vulnerability of communities in terms of cumulative loss of small vegetation remnants. Threshold limits to permissible clearing should vary across vegeta tion communities, dependent on the historical patchiness of the vegetation community as well as the contribution of small patches to the remaining extent. Our approach will improve our ability to evaluate overall change (e.g. through environmental accounts), explicitly consider and prioritize management actions to inform conservation planning (Margules & Pressey 2000) and evaluate the impact of potentially destructive activities such as devel opment and extraction.

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Data accessibility

The Australian Government National Vegetation Information System (NVIS Version 4.1) is freely available for download (http://www.environment.gov.au/):

1. Estimated Pre1750 Major Vegetation Subgroups: http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid %7BD3589075-58CD-4D4B-B46D-1F16AF8D2ADE%7D

2. Present Major Vegetation Subgroups: http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid %7B21a53368-c383-4ec1-bf51-878b369ce303%7D

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Supporting Information

Additional Supporting Information may be found in the online version of this article.

Appendix S1. Details of loss and fragmentation analyses for all vegetation communities.

Appendix S2. Metric comparisons and supporting code.

Appendix S3. Characterizing community change.

Fig. S1. Percentage change in the overall extent, and number of patches, of the 75 broad vegetation communities (as defined by NVIS) in Australia.

Fig. S2. Relative change in vegetation community extent versus (a) a traditional edge metric measuring fragmentation [Fragmentation quotient, F $(A_0/A_1)/(E_0/E_1)^2$] and (b) total change in contribu tion of patches <5000 ha.

Table S1. Results of patch threshold metrics and Gini coefficient for all 75 NVIS vegetation communities.

Table S2. Ranks of the 75 vegetation communities with respect to the three measures of loss, fragmentation and equality.

Table S3. Size of the patch at varying thresholds of cumulative extent for all 84 vegetation communities based on current condi tions.

Table S4. Size of the patch at varying thresholds of cumulative extent for all 75 vegetation communities based on 1750 conditions.

Table S5. Results of Kolmogorov Smirnov tests to determine if the distributions of patch sizes for all 75 vegetation communities based on pre 1750 conditions differ from the current patch size distribu tions of those communities.

Table S6. Characteristics of loss and fragmentation of vegetation communities in Australia.

EXHIBIT 3

INTRODUCTION AND PURPOSE OF THE DESIGN GUIDE

This Design Guide is intended to clarify the Chapter 1 of the Water Resources Infrastructure Protection Manual, section VIII, articles D-H (Outfalls, Pump stations and Site Drainage). This Design Guide describes how to address streambank erosion problems, and how to use bioengineered methods of bank protection and erosion repair.

This Design Guide is to be used by local permitting agencies, property owners and professionals who design projects on streamside parcels (i.e. civil engineers, land use planners, landscape architects, etc..) It is intended to:

- Provide guidance for how to design a variety of bank protection projects, in places where streambanks are, have, or may be eroding
- Promote proactive approach to preventing and resolving serious erosion problems

This document is a guide, not an instruction manual. Erosion repair activities within a stream channel will impact water quality, flood protection, the stability of adjacent properties, and the habitats of many stream-dependant species. It is for these reasons that these activities require several state and federal permits, as well as the involvement of qualified professionals to help design and construct the project in a way that addresses stability and long-term water resource protection. Examples of more detailed guidance manuals are listed at the end of this document for reference.

MOVING TOWARD SOFT, MORE SYSTEMIC METHODS OF BANK PROTECTION/EROSION REPAIR

Traditional methods of controlling erosion have relied on "hard" structural practices such as covering banks with interlocking concrete blocks and building retaining walls. However, these techniques often have negative impacts on streams. In many cases, these methods are also expensive and ineffective in the long run. Recommended instead are "soft" or bioengineered bank stabilization methods. A bioengineered approach involves the planting of native streamside or riparian vegetation combined with the strategic placement of logs or minimal rock, where necessary, and regrading of steep slopes wherever possible in order to produce living systems that minimize erosion, control sediment, and provide habitat. The natural attributes of plants, when combined with stabilized bank slopes, provide better dynamic stream systems than stationary hard structures.

An objective of this Design Guide is to protect, and where appropriate, restore streambanks and related stream resources. Where suitable, it encourages a systemic approach to streambank protection and stream restoration. This Design Guide starts by describing how streams function, typical features of a stream and importance of riparian vegetation. It then discusses typical causes of streambank erosion and recommends basic measures to be considered when planning and designing a bank protection erosion repair project. Finally, alternative methods of protecting a streambank are presented, starting with how to treat a reach of a stream in a more rural setting where there is room to use a more systemic approach, and continuing with a variety of treatments for smaller, urban parcels, which include a small reach of a stream.

GOALS/PURPOSE OF STREAMBANK PROTECTION ACTIVITIES

In general, the goals of any bank protection/ erosion repair activity should be to:

- Maintain or increase stream stability and facilitate transport of sediment and water;
- Avoid localized solutions that repair only a single erosion site but reduce the stability of neighboring stream banks

and cause erosion problems on upstream or downstream properties;

- Enhance and increase native vegetation both in extent and diversity to provide habitat value and help ensure long-term bank stability.

With these goals in mind, this Design Guide delineates some general guidelines and issues to consider when embarking on a bank-protection/erosion-repair project, as well as a description of various erosion-repair techniques. This guidance also provides agency staff and streamside property owners with a brief overview of how streams are formed, their common characteristics and features, and typical causes of streambank erosion

ORGANIZATION OF THIS DESIGN GUIDE

This Design Guide is organized into two parts and six subsections. The Technical Primer part includes useful background information that explains the causes of erosion. Homeowners and project developers will likely refer to the Techniques and Guidance part more frequently, because it outlines techniques and guidelines for erosion repair.

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PART ONE: TECHNICAL PRIMER ON STREAM FUNCTION AND FORM

SECTION 1 - HOW STREAMS FUNCTION

INTRODUCTION

Before considering bank protection or erosion repair, it is necessary to understand the process by which streams form and adjust to their surroundings. Streams are shaped by a combination of "forming forces" that include:

- Gravity, or the slope of the channel banks
- Friction, which is a function of vegetation, the soil's type and particle size, and the channel's pattern and profile.
- Velocity, the speed of the water flow.
- Quantity, the volume of water flowing and sediment moving through the stream.

Over time, streams move and shift in response to changes in these forming forces. That is why streams do not naturally tend to flow in a straight line. Instead, they meander in search of equilibrium with their forming forces, adjusting to changes in water flow and sediment transport. These changes can have both natural and non-natural causes.

CHARACTERISTICS AND HISTORY OF STREAMS IN SANTA CLARA COUNTY

Some streams in Santa Clara County are still in a natural condition, while others have been straightened or channelized in response to land development activities and flood control needs. Throughout the County, human-made channels were created to contain the flows that once naturally fanned out over the valley floor, carrying with them nutrients and sediment, and creating alluvial fans and fresh water marsh habitat. These human-made channels were created to accommodate the use of land for agriculture or urban development, and to ameliorate flooding conditions.

Experience has also shown, however, that significant problems arise when streams in the lower watershed are confined. By lining streams with levees or floodwalls, water that would otherwise slowly spread out over a large area of land in a beneficial way accumulates in the channel until it breaches its levee or floodwall, potentially causing catastrophic flooding. Even if this does not happen, a significant amount of sediment may be deposited in the channel after a storm event, raising the channel bed elevation. This sediment decreases the channel's capacity to handle subsequent storm flow. In other words, the chance of catastrophic flooding increases with every storm if the channel's sediment is not removed often enough.

Significant efforts are underway throughout the County to address these issues, and to maintain and enhance our remaining natural streams. There are also efforts being made to restore and enhance, where possible, channelized urban drainage ways. It is important to remember that even though a stream may be hardened or modified in a particular location, it may remain natural in other areas. Over time, it may be possible and even essential to restore these streams to a more natural state to improve stability and flood protection for nearby property owners.

In addition, the protection of water quality is critical in all types of Santa Clara County streams, both natural and unnatural, because they eventually convey water to either Monterey Bay or San Francisco Bay.

TYPICAL STREAM FEATURES

In a cross-sectional view, a stable natural stream can be defined by two significant features: the "bankfull" (or "active channel") and the "active floodplain." See figure 1 below.

The bankfull or "active channel" can be defined by the elevation of the floodplain, which is formed by the most effective channel forming or "dominant" stream discharge. It is the part of the stream where sediment is actively transported and deposited, the part that is capable of containing the most frequent flows.

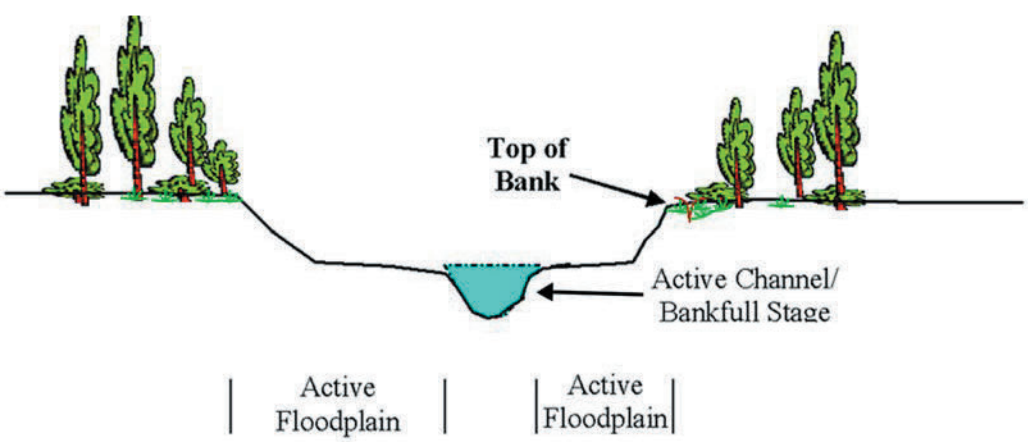
The active channel is an important feature because it transports the majority of the water and sediment in the stream system, and thus it influences the channel formation over time. As seen in Figure 1, the active channel is usually distinguished from the active floodplain by an abrupt change in the slope of the stream bank, usually from a vertically-sloped plane to the horizontally-sloped plane on top of the floodplain.

Active floodplains are the low-lying areas between Top of Bank (See Figure 1) and adjacent to the active channel that are subject to frequent inundation during moderate and high flows. This area is where sediment is deposited when the active channel's capacity is exceeded during high flows. In urban settings, active floodplains are often hard to identify, due to channel incision and erosion from increased urban runoff. On rural streams, the active floodplain normally fills approximately every year or two. Floodplain filling usually occurs more often in urban areas. Vegetation is typically present in the floodplain area, as it will become established between the alternating seasonal periods of inundation and sediment deposition.

(Section 2 of the Guidelines and Standards also includes more detailed definitions and sketches showing these features in a variety of settings).

Important Note: A stream's active floodplain is not to be confused with the delineation of floodplain used for flood insurance purposes. The floodplain defined for flood insurance purposes is the one percent (100-year) flood, or the area that has a one percent chance of being flooded to a depth of one foot or greater each year. For insurance purposes, this equates to a 26 percent chance of suffering some flood damage during the term of a 30-year mortgage.

FIGURE 1: CROSS-SECTIONAL VIEW OF A NATURAL STREAM



STREAM BELTWIDTH AND STREAM MEANDER WIDTH

A channel has a certain beltwidth within which it naturally moves. This beltwidth can be determined by studying: sections of the channel which have not been straightened; pre-development photographs; or, adjacent similar channels. Levees should not, for example, be constructed in a way that does not accommodate the beltwidth. Doing otherwise increases erosion potential and maintenance costs.

Meander width is the amplitude of the meander within the beltwidth. It is smaller than the beltwidth. At a minimum, the average meander width of a channel should not be compromised in the lower flood plains. In the mid to upper slopes above the valley floor, where the natural channel may be fairly straight, the beltwidth should also be respected.

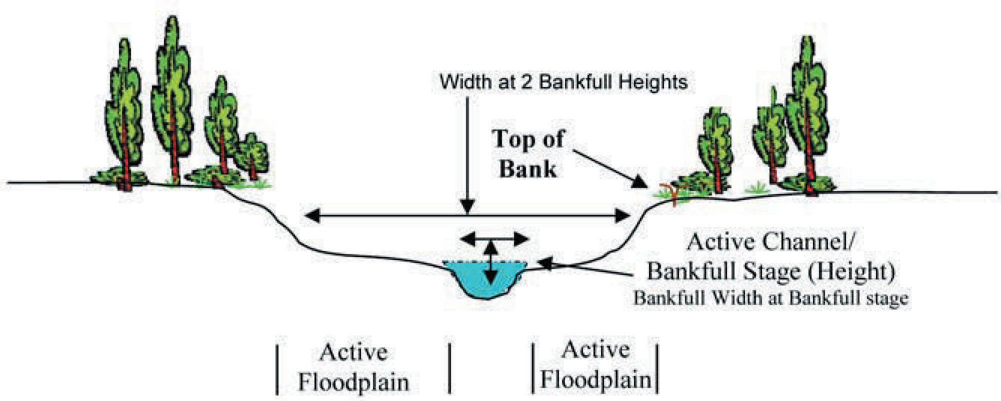
FACTORS THAT AFFECT STREAM STABILITY

Several factors affect stream stability. They include stream topography, the width-to-depth ratio, and extent of channel incision

The quantity and movement of both water and sediment in a stream are two of the primary influences on the topography of a stream. These materials tend to balance each other within the confines of the stream channel. For example, erosion on one bank is typically balanced by sediment deposition on the other. While the location and extent of the erosion and resulting deposition may change over time, the width and depth of a stable stream does not change much. Thus, any type of erosion repair project must be designed to maintain width-to-depth ratio in order to ensure long-term stream stability, while also allowing the streambed to erode and fill naturally.

A channel's width-to-depth ratio is calculated by dividing the width of the stream channel (at the bankfull level) by the mean channel depth. Width-to-depth ratio is part of a more complicated concept called entrenchment ratio, which is important because it calculates a channel's stability. Generally speaking, it calculates its stability in terms of its floodplain—the larger the floodplain, the higher the entrenchment ratio. Specifically the entrenchment ratio is equal to the width of the stream channel (at twice the maximum bankfull depth) divided by the width-to-depth ratio of the bankfull channel. In order to prevent channel incision and maintain a stable stream, the ratio of the width of the channel at 2 bankfull heights (see Figure 2) to the bankfull width should be a minimum of 2 where the channel is constrained. It should be a 3 to 4 ratio at other locations, both upstream and downstream. This provides sufficient relief, and thus prevents excessive erosion of streambed and bank. It also prevents damage to bankside properties during 1 year–10 year storm events.

FIGURE 2. DETERMINING THE APPROPRIATE WIDTH TO DEPTH RATIO



EFFECTS OF WATER AND SEDIMENT TRANSPORT ON BANK STABILITY

Streams adjust themselves to transport, as efficiently as possible, water and sediment from higher elevations to lower elevations. If the amount of sediment available to a creek is significantly increased or decreased, the creek adjusts its channel area or cross section to handle the change in sediment. In a normally-functioning gravel bed stream, for example, it is not uncommon for the stream channel (or portions of the stream channel) to downcut and refill significantly—from a few inches to 10 feet or more in a single storm event. This is one way streams transport their sediment loads, clean themselves, and temporarily increase their flow capacity.

With the expanded development in Santa Clara County, the time it takes for runoff to reach the streams has decreased, which leads to the increase in the amount of water in most streams. Some of the specific factors that have led to this increase in water flows are:

- Substantial increases in impervious surfaces such as pavement and roof tops.
- The routing of storm water runoff directly into streams through piped storm drain systems.
- Removal of large areas of streamside vegetation that would otherwise form buffers for runoff, and promote infiltration into the soil.

The stormwater management programs of local municipalities have efforts underway to address these long-term issues. In the interim, however, it is important that armoring the channel be avoided on individual properties whenever possible, for several reasons. First bank armoring prevents channels from adjusting to high flows, and can increase the probability of flooding. Bank armoring also causes accelerated flow velocities and turbulence along banks, which then induces more erosion on unarmored banks. Finally, because armored banks cannot adjust to changing stream conditions, they are prone to undercutting.

IMPORTANCE OF VEGETATION AND RIPARIAN BUFFERS

The roots of well-established vegetation not only protect the surface of stream banks, but also penetrate deeply into the ground, helping to stabilizing it. Lack of vegetation close to a creek bank can contribute to slope instability and failure due to overbank drainage or soil saturation. In addition to providing bank stability, streamside vegetation filters pollutants; shades and cools the stream; increases infiltration; reduces flash runoff; and provides habitat for wildlife. A variety of scientific studies of the minimum and optimum width of a vegetated buffer along a stream indicate that a width of 10 feet is not enough to provide adequate filtration or habitat. A study by U.S. Fish and Wildlife indicates that in order to effectively remove pollutants, a buffer of 50 feet is needed. Other sources recommend a vegetated buffer that is 2 to 5 times the width of the stream channel. While there is ongoing discussion about the most appropriate width for vegetated buffers, it is conclusive that at least some adequate buffer is necessary to protect stream resources. In terms of erosion repair projects, the use of live plants, either alone or in combination with dead or select rock materials, can be sufficient to prevent erosion, control sediment, and provide habitat.

STREAM FEATURES THAT ARE IMPORTANT TO FISH HABITAT

The movement of water through a streambed creates certain natural characteristics or that benefit fish habitat. Some of these important features are riffles, runs, glides and pools. Riffles are located in shallow areas or bends in a stream where water flows over rocks. Runs are the straight sections between riffles. Glides are the transition areas between the downstream end of pools and a run or riffle. Pools are usually formed on the outside of bends in a stream. Deep pools are particularly import ant in providing critical fish habitat and refuge areas. When the flow in the stream decreases in drought, fish can retreat to these pools to wait for the return of higher flows.

These stream features described above differ from stream to stream depending on a stream's geometry and location. For example, at higher elevations, stream channels are steeper, narrower, and drop at faster rates, and may contain series of step-pool cascades. At a lower elevation, however, a channel tends to be less steep, wider, and more sinuous, making riffles and pools more common. The combination of riffles, runs and pools is extremely important for fish because it provides different feeding, spawning and/or nursery areas. These stream characteristics should be preserved, restored, and enhanced where possible, as appropriate to the stream topography, in any type of erosion repair effort.

SECTION 2 - CAUSES OF STREAM BANK EROSION

All streams erode to some extent as a part of natural processes. Natural erosion is typically caused by:

1) Hydraulic forces that remove bank material;

2) Geotechnical instabilities;

3) Or, most commonly, a combination of both these two forces.

HYDRAULIC FAILURES

Hydraulic failures occur when the force or velocity of the water is greater than the natural cohesion of the soil. In other words, the forces that bind the soil together are overcome by the water. Some visible features of hydraulic failures are erosion near the bottom, (or at the "toe,") of a stream bank, or alteration of the streambed. Changes in the direction of flow, constrictions, increases or decreases in the amount of sediment, and increased amount and duration of flow from impervious areas can all accelerate erosion of the stream bank or alteration of the streambed, and in turn, hydraulic failure.

Some of the sediment that is introduced into the stream will naturally deposit on the bottom of the stream. Over time, this may raise the bottom of the stream and reduce the capacity of the active channel, forcing the water to spread out laterally. This causes erosion and steepening of the stream banks. This can also occur when a stream is starved of sediment (typically by dams or erosion control structures) and the excess energy that would have been used to transport sediment is now free to erode bed and banks. This condition typically occurs with the construction of hardened channel linings, or with the addition of other types of instream debris, sediment, or detention basins that trap sediment. In this case, the erosion (down-cutting and steepening) of the streambed and banks occurs below the lined section (or "instream basin"), causing the eroded sediment to settle farther downstream. Nonetheless, the impact on the stream is similar. Thus, for hydraulic failures, the most effective erosion repairs are accomplished by addressing the root cause of the failure, which may include installation of measures to redirect flow, increasing the erosion resistance of the bank, by planting vegetation on the bank or adding protection to the toe of the stream bank.

GEOTECHNICAL FAILURES

Geotechnical failures occur when gravitational forces are greater than the strength of the soil. These failures are usually caused by over steepened banks and/or excess moisture in the soil. This results in the movement of earth, better known as a landslide. Near a stream, the likely causes of this type of failure are a high groundwater table, poorly designed surface drainage systems (such as those that drain surface runoff directly over the top of the stream bank), leaking swimming pools, and leaking septic systems or water lines (which saturate the stream bank). Thus, for most geotechnical failures, what must be addressed is the source of the water that's causing excess moisture in the vicinity of the stream bank.

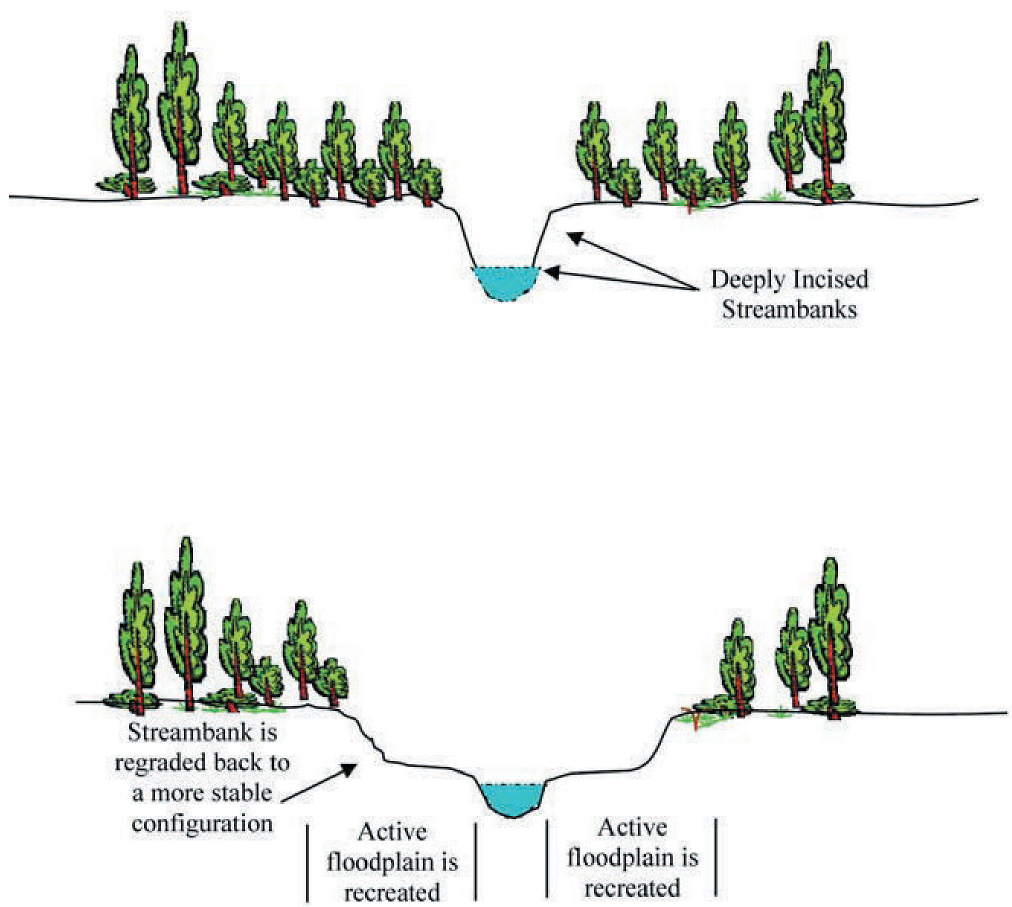
COMBINATION FAILURES

The third type of failure is a combination of hydraulic forces and geotechnical instabilities. Hydraulic failures often lead to geotechnical failures. As the toe of the stream bank erodes, or the channel cuts downward because of hydraulic forces, the bank effectively increases in height and becomes too steep and unstable. Sometimes, the upper portion of the stream bank fails from lack of support, and slides into the stream. This process is well described in the document Maintaining Corte madera Creek: A Citizen's Guide to Creek-side Property Protection, which was prepared by Phil Williams and Associates in Collaboration with H. T. Harvey and Associates for the San Francisquito Creek Joint Powers Authority. They write, "The higher a bank is, the flatter the angle must be to prevent slumping. For example, most soils will support a three-foot high vertical bank, but if the river cuts a deeper channel (say five feet) the bank will collapse under its own weight. A five-foot tall bank would need to be graded to a lower gradient to be as stable as a three-foot vertical bank, and a ten-foot high bank would have to be excavated to an even lower gradient to be stable. The higher the bank, the lower the stable gradient becomes." The best remedy for this problem—the problem of an over-steepened bank experiencing both hydraulic and geotechnical failures—combines several steps. The first step involves regrading the slope to a more stable angle, which is why it is called "laying it back."

The second step involves reinforcing the toe, where necessary, with biotechnical methods such as logs and rocks. The third step involves reducing erosive energy on the bank by planting the bank, so that it does not become over-steepened again.

For an illustration, see figure 3 below.

FIGURE 3: LAYING BACK A STREAMBANK TO INCREASE STABILITY



PART TWO:
TECHNIQUES AND GUIDANCE FOR DEVELOPING A WATERSHED-FRIENDLY EROSION REPAIR PROJECT.

SECTION 3 - EMBARKING ON YOUR BANK PROTECTION/EROSION REPAIR PROJECT

This section describes five initial steps to consider in undertaking an erosion repair project. This text borrows extensively from the guidance manual developed for the Guadalupe and Alamitos Creeks entitled "Stream-bank Repair Guidance Manual for the Private Landowner," which is cited in the references section.

INITIAL STEPS

Step 1: Establish the Purpose and Necessity of Your Project

Step 2: Hire Qualified Professionals

Step 3: Get to the Root of the Problem

Step 4: Seek Assistance from the Water District

Step 5: Secure Permits from the Appropriate State and Federal Agencies

STEP 1. ESTABLISH THE PURPOSE AND NECESSITY OF YOUR PROJECT

Repairing a stream or bank erosion problem is not a simple or routine task. The root cause of the bank failure must first be identified. Then, the most probable stable channel form and dimensions must be determined, based on geomorphology and hydrology, as well as hydraulic analyses. Only then can a proper solution or repair be recommended.

Before embarking on any bank stabilization/ erosion repair project, it is important to answer the following questions: What is the purpose of this project? What are its objectives? Is it necessary?

Some examples of objectives could include:

- Protecting property or structures
- Restoring eroded banks
- Protecting existing banks from erosion
- Restoring riparian habitat and improving stream function

Determination of the project's necessity must take into account the fact that some erosion is natural and acceptable. For example, the exposure of roots on a streamside tree is natural, and unless extreme, it will not hurt the tree. If the bank height is less than about eight feet, what is easily perceived as bank erosion may be only temporary, or even reverse itself as the stream meanders in its floodplain. Some erosion repair activities, such as bank armoring, can destabilize other areas erosive forces are transferred downstream, or onto opposite banks, eventually causing additional problems. A qualified professional may be needed to help determine whether, and to what extent, erosion is in need of repair.

STEP 2. HIRE A QUALIFIED EXPERT TO DETERMINE THE APPROPRIATE DESIGN

Designing an erosion repair project that maximizes stability and avoids unintended consequences is complicated. As noted earlier, a stream must have a properly dimensioned bankfull channel in order for it to have long-term stability. Other critical factors in proper channel design include: proper width to depth ratio, water velocity, sheer stress, and channel slope. Most property owners do not have the training or expertise necessary to incorporate all of these considerations into project design.

A walk along many Santa Clara County streams proves this point. It reveals many examples of how individual property owners, without professional help, tried to control streambank erosion by armoring the bank. These measures often fail to address the need to reduce shear stresses in order to keep the bed and banks from eroding. Eventually, the channel will downcut, and in most cases, fail. Professionals can help avoid this kind of failure-prone approach to streambank repair and help identify and address the root cause of the problem.

STEP 3. IDENTIFY THE SOURCE OF THE PROBLEM

It is important to identify and, if possible, address that the source of streambank or bed erosion. If it is not addressed, the erosion repair project may either need to be repeated or expanded in the future, or cause other erosion problems upstream, downstream, or across the stream. To identify a potential source, one should look for:

- Flow constrictions like bridges or debris that increase downstream velocities and shear stress,
- Existing hardscape, or paved over areas, that may be increasing velocities downstream,
- Natural or non-natural debris that may have redirected the flow into the bank,
- Drainage features that may be directing flow onto, or saturating, the bank,
- Watershed-wide increases in amount and duration of runoff that may be causing systematic degradation of the creek channel (incision), which leads to toe failures and bank slumps.

These underlying causes of erosion could be natural features or constrictions, but most likely, they are non-natural, i.e., human-made. Oftentimes, the source of the problem is an earlier effort to address an erosion problem upstream or downstream. Depending on the extent of the problem, it may be worthwhile for the property owner to consider a collective effort with neighboring property-owners, perhaps even including government and/or public agencies who own land or rights-of-way in or near the stream.

Because actions taken to address erosion in one place can cause problems elsewhere, permit applicants should consider the potential impacts on both the downstream and upstream streambed and banks when determining the type of erosion repair measure to use. To this end, property owners may be asked to provide professional analyses of stream geomorphology and/or hydraulics to determine potential negative impacts, and recommend ways to prevent them.

STEP 4. SEEK ASSISTANCE FROM THE SANTA CLARA VALLEY WATER DISTRICT (SCVWD)

For SCVWD's assistance in conducting repair or maintenance, contact the SCVWD's Watershed staff at 408.265.2600. There are three different scenarios related to ownership and easement that determine assistance eligibility:

SCVWD RIGHT OF WAY: If the District owns the property where the stream is located, District staff will visit the site to inspect the erosion, determine if and how it should be addressed, and then, if need be, take appropriate measures to do so.

SCVWD EASEMENT: If the District has an easement on the section of the stream needing repairs, District staff will visit the site to inspect the erosion. Easements generally provide the District with the necessary rights to perform the work. The District can make repairs within an easement after assessing the extent of the erosion, the infrastructure affected, the available funding, and the need to conduct other work on District property.

PRIVATE OWNERSHIP: If the stream is under private ownership, District staff is generally available for a visit to the site, however this availability will depend on the number of requests received and staff resources. Staff can provide advice on an approach to use but, the District will not design or construct the project.

Requests for technical assistance for minor erosion repair work can be submitted to the District via their web site at http://www.valleywater.org/Water/Watersheds_-_streams_and_floods/Taking_care_of_streams/Service_request_form.cfm. To negotiate an agreement for assistance on a substantial repair project, contact the District's Watershed staff at 408.265.2600.

STEP 5. SECURE PERMITS FROM FEDERAL, STATE AND/OR LOCAL RESOURCE AGENCIES

Most erosion repair projects will require permits from federal, state and/or local regulatory agencies if they entail construction between the banks of a stream. Please refer to the Resource Agency Referral List in Section 6 of this Design Guide for a list of all the agencies, the types of activities for which they should be contacted, and their contact information. The San Francisco Bay Area Joint Aquatic Resource Permit Application (JARPA) consolidates the information that permitting agencies require into a single application. The JARPA application can be found at:

http://www.abag.ca.gov/bayarea/sfep/projects/JARPA/JARPA.html

The permitting process can take as little as a few weeks to complete, but typically takes a few months, depending on the complexity of the project and the presence (or potential presence) of federal of state listed endangered, threatened or special status species of plants or animals. Typically, the U.S. Army Corps of Engineers, the Regional Water Quality Control Board, and California Department of Fish and Game will issue permits under federal and state laws, while the Santa Clara Valley Water District or the local municipality acts as the local permitting agency.

IMPORTANT NOTE: Bank repair designs that avoid or minimize hardscape and are based on sufficient analysis of the cause of failure and stable channel characteristics almost always receive permits more readily than those that do not. Do not hesitate to contact agency representatives early in the design process to determine whether you need a permit from their agency, and to discuss potential repair options if you do.

SECTION 4 – GENERAL GUIDANCE FOR WATERSHED FRIENDLY DESIGN

USE VEGETATION TO RESTORE AND MAINTAIN STABILITY

Revegetation of the streambank is one of the most common, and often the most effective, way to prevent erosion along a streambank. This is because roots bind soils together, which prevents erosion, while leaves provide protection from rain splash erosion. In addition, the exposed trunks and stalks provide resistance to stream flow because they slow the water and decrease its erosive energy. An added benefit is that vegetation provides ideal habitat for birds and other animals. Vegetation planting methods commonly used include cuttings, transplants, live staking, and direct seeding (including hydro-seeding).

- Maintain streamside trees. Avoid pruning trees unless it is necessary to the survival of the plant or the protection of existing property and/or infrastructure as trees can critical shelter and shade for stream wildlife.
- Do not remove affixed logs. Logs that have been permanently or securely affixed to the streambank provide valuable habitat. Their removal could negatively impact fish habitat, and might therefore require mitigation. However, downed trees and logs can often deflect high flows, causing serious bed and bank erosion, destroying fish habitat, and degrading water quality. For these reasons, downed trees and logs need to be removed quickly.
- Plant between October 15 and March 15. In order to minimize irrigation requirements and ensure that plants receive sufficient water for natural propagation, plant in the fall and early winter. Where soils are dry and water is limited, irrigate as needed until the rainy season.
- Do not introduce invasive non-native vegetation species into the watershed. Non-native invasive plants are a serious problem because they often inappropriately constrict water flows and overtake native plant species.(See Design Guide 2 for more on invasive non-natives).
- Instead, use locally collected native species for revegetation and replacement plantings. Plant selection and density should be informed by a survey of natural areas on the same creek that have a similar ecological setting. This can inform you as to what species would be found in the area and an approximate population density. See Design Guide 4 and 5.
- Plant according to moisture needs, using different types of vegetation on the upper and lower sections of the stream bank. Plants have different tolerances for the wet conditions at the toe of slope. They also vary in drought-tolerance and erosion-control effectiveness on the upper slopes. Some tree species, such as willows and cottonwoods, are more successful when they are closer to the stream. Others, like oaks, enjoy more success higher up the bank. Where stream capacity is an issue for flood protection purposes, choose vegetation that is flexible and that will not collect debris and slow high flows during flood events.
- Use fast-sprouting grass species for more immediate erosion control. A regraded slope can be seeded with fast-sprouting grass species such as sterile wheat, or better yet, a native grass/sedge seed mix combined with a biodegradable erosion control blanket. These species provide more immediate erosion control.

See Design Guides 4 and 5 for plant species.

- Do not use chemical fertilizers, herbicides or pesticides. These chemicals can be easily transported to the creek by wind or rain and degrade water quality, endangering aquatic life.

WATERSHED-FRIENDLY DESIGN: BEST MANAGEMENT PRACTICES

This section provides some tips for stream care during construction. Proper use of best management practices (BMPs) can have a tremendously beneficial impact on aquatic species and other wildlife, human health, environment, property, and public services.

CONSTRUCTION BMPS:

- **When restoring a damaged section of a streambank, imitate natural stream features**, such as channel meanders, appropriate width and depth, and vegetation. This will stabilize the channel. Details of this concept are included in Section 5 of this Design Guide.
- **Observe work windows**. In-channel work should generally be conducted during the dry season, between June15th and October 15th, to minimize negative impacts to plant and wildlife. Sometimes these dates will vary depending on the wildlife species in the area. Do not use heavy equipment during spawning or migration seasons, as it can destroy fish habitat. If construction during periods of stream flow can not be avoided, include measures to separate area of disturbance from stream flow to minimize turbidity in stream.
- **Avoid removing in-stream gravel.** Avoid disturbing the creek bed, particularly spawning gravel. After project completion, replace or restore any gravel that was moved or removed to maintain spawning areas for fish.
- Take special care when establishing stream access points, because these points can contribute undesirable sediment to the stream. So
    - Use established access point wherever possible.
    - If it is necessary to create a temporary access point for construction, do so as close to the work area as possible in order to minimize adverse impacts. When the project is complete, restore the access Point to as natural and stable condition as possible.
    - Prevent soil at construction entrances from being tracked onto streets near work sites.
- **Control dust**. Dust can be a nuisance, and have an adverse impact on water quality.

  To control dust:

    - Water active maintenance areas so that they are sufficiently moist to prevent dust.
    - Sweep any paved access roads of visible soil material.
    - Cover trucks hauling sediment, ensure that their tailgates are closed, and brush off any excess dirt.
- **Store and secure materials.** Remove all building materials, debris, lumber, et cetera within 2 days of completing the project.
- **Be wary of mercury and other contaminants**. Disturbed or excavated soils in areas where soils are known to contain mercury or other contaminants should be removed or properly capped if the soil will be exposed to flood flows. In areas whose soils are known to contain mercury, remediate the disturbed or excavated soils if they are exposed to flood flows. Wear protective equipment. Consult the Santa Clara Valley Water District for disposal guidance.

FOLLOW-UP MAINTENANCE:

Do not neglect stream-bank repair after construction is over. Minor maintenance activities help ensure a project's success.

- **Remove trash and debris.** Sometimes, the accumulation of debris in the channel causes erosion on nearby banks. So:
    - Regularly remove debris such as trash and human-caused debris.
    - Do not put yard waste in the creeks or on the banks, where leaves and clippings can wash into the stream.
- **If mulching:**
    - Use biodegradable erosion control blankets on bare slopes or if it is too late in the season to establish vegetation. The blankets will last for 1 to 3 years while natives reseed.

      Monitor the success of natural revegetation before taking aggressive action to revegetate.
    - Woody debris from the site might make for suitable mulch.
    - Use bark and other wood products or fabric blankets above the high water line to prevent erosion of bare soil after construction is completed.
    - Use weed-free certified mulch.
    - Do not use Eucalyptus, Walnut, or Tree of Heaven. They produce an allelopathic compound that can be toxic to plants and aquatic organisms.
- **Be careful when trying to control rodents**. Burrowing rodents may be a nuisance and can damage levees on streams, but do not use rodenticides. Their effect on the local habitat is too destructive. Instead, consult County Vector Control.
- **Revegetate**. In areas that have been revegetated, replace dead or dying plants and weeds. Remove non-native plant colonizers. Ensure that all plants receive sufficient water.

SECTION 5 - DETAILED DESCRIPTIONS OF EROSION REPAIR TECHNIQUES

Described in this section are 16 different types of erosion repair methods. Each description contains a brief overview of the repair method, the circumstances in which it is most appropriate, its anticipated environmental value, its relative costs, and its potential impacts. Descriptions are not exhaustive, and should only be used in conjunction with consultation from a qualified erosion repair professional, the Santa Clara Valley Water District, and relevant regulatory agencies.

Even the most well-meaning erosion repair designs can have negative impacts on a stream if they are not planned, designed, and constructed properly. Poorly placed rocks or woody material can cause bed and bank scour/erosion, excessive sediment deposition, and/or decreased channel capacity. For this reason, it is essential that the project is designed to accommodate the site's particular geomorphic location, channel form and depth, flow velocity, and site constraints. This typically requires a physical, or "geomorphic" assessment by a trained professional.

To protect both your property and its value, the goals of any streamside bank protection or erosion repair project should be to restore stability and leave the site in a better ecological condition than it was before. The first erosion repair method, the modified flood plain, will provide the best long term, ecologically friendly and most stable results. Methods 2 through 8 use bioengineering methods. Bioengineered bank stabilization methods typically involve two components:

- Regrading the upper streambank to establish or re-establish a floodplain, with terraces where possible.
- Planting native riparian vegetation on the streambank and terraces in order to restore and provide long-term stability.

If soft methods of protection are not feasible due to highly erosive forces, then there is probably a channel dimension, hydrology and/or morphology problem.

Hard bank protection can cause more erosion and damage in the channel, along the downstream and/or upstream banks, as well as on the opposite bank of the repair site. Any consideration of the use of hardened materials should be with caution and with an assessment of the impacts that may occur.

Erosion repair methods 9 thorough 11, incorporate bank armoring which should be avoided. The use of log and rock flow deflecting structures as described in method 1 is less expensive and a more environmentally friendly way of protecting banks from erosion. Detailed guidance of these methods is beyond the scope of this Design Guide but should be considered by the design professional.

Erosion repair methods 12 through 16 are NOT recommended. However, they may be necessary when the site is constrained, or where the water volume, velocity, bank steepness, and resultant erosive forces necessitate the use of more extreme methods

TABLE 1: PREFERRED EROSION REPAIR METHODS

Repair Method	Appropriate Slope	Appropriate Water Velocity	Environ Value	Cost
1. Modified floodplain	Varies	Varies	Positive	Low
2. Slope Grading with Vegetation	2:1 or flatter for vegetation section, 1.5:1 or flatter for boulder section.	Low – typically up to 6 ft/sec	Positive	Low
3. Erosion Mats	2:1 or flatter for erosion mat section, 1.5:1 or flatter if boulders used.	Generally 1-7 ft/sec but can go up to12ft/sec if vegetated.	Positive, if planted.	Low
4. Contour Wattling		Low	Positive	Low
5. Brush Mattresses	2:1 or flatter for erosion mat section, 1.5:1 or flatter if boulders used.	Low	Positive	Low
6. Brush Layering	2:01	Medium	Positive	Low
7. Vegetated Geogrids or Soil Lifts	Up to 1:1	Medium	Positive	Low
8. Root wads and boulders		Medium: (10 ft/sec or less)	Positive, if planted	High
9. Boulder/ Rock Revetment	Up to 1:1, preferably 2:1.	High: up to 15 ft/sec; less where voids in boulders are planted.	Negative. Negative to Neutral, if planted	Medium
10. Cellular Confinement System	Up to 0.5 to 1	Medium to High:5-21 ft/sec depending on vegetation)	Neutral	Medium
11. Live Log Crib Walls	Up to 0.25:1	Medium: up to 12 ft/sec or less	Neutral to High, if planted	High

#1 MODIFIED FLOODPLAIN HOW TO CREATE A MODIFIED FLOODPLAIN

The modified flood plain design provides the optimum solution for long-term, ecologically-friendly, and less expensive stability. In urban areas property owners typically have short stretches of stream running through their property and often only on one side of the stream. The cooperative enlisting of neighbors to affect this approach is well worth the effort. The typical steps in creating a modified floodplain are:

Step 1: Identify the appropriate channel width and depth, at bankfull level. The active channel will contain flows resulting from small frequent rainfall events.

Step 2: Identify the appropriate elevation for the floodplain area, and determine how much space is available and appropriate for widening the banks.

Step 3: Regrade or lay back the existing bank above the floodplain to a flatter, more stable angle (usually a 2 horizontal to 1 vertical slope, or greater);

Step 4: Create terraces above the active floodplain to accommodate vegetation

Step 5: Plant the terraces with appropriate local, native, riparian vegetation to stabilize the bank(s) and create habitat.

HOW TO CREATE A MODIFIED FLOODPLAIN IN DEEPLY INCISED CHANNELS

A watershed-friendly design that recreates a natural floodplain is depicted in Figures 4 and 5 below:

FIGURE 4: STREAM CHANNEL WITH DEEPLY INCISED STREAMBANKS

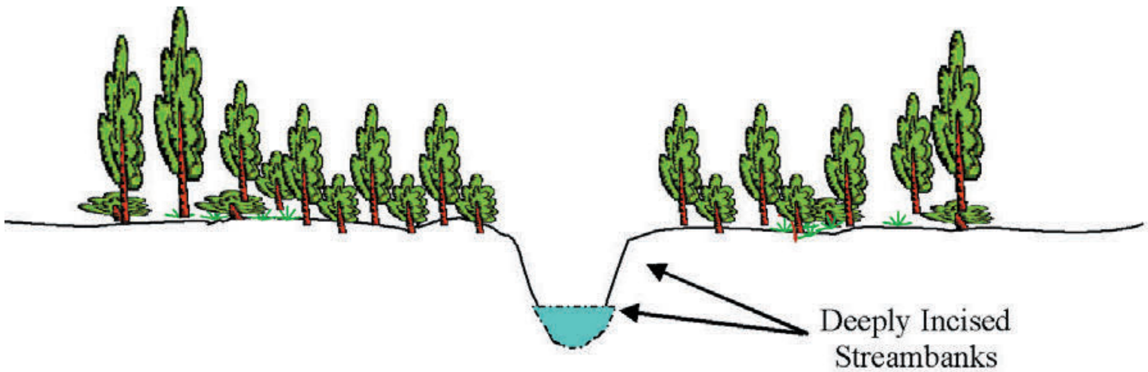
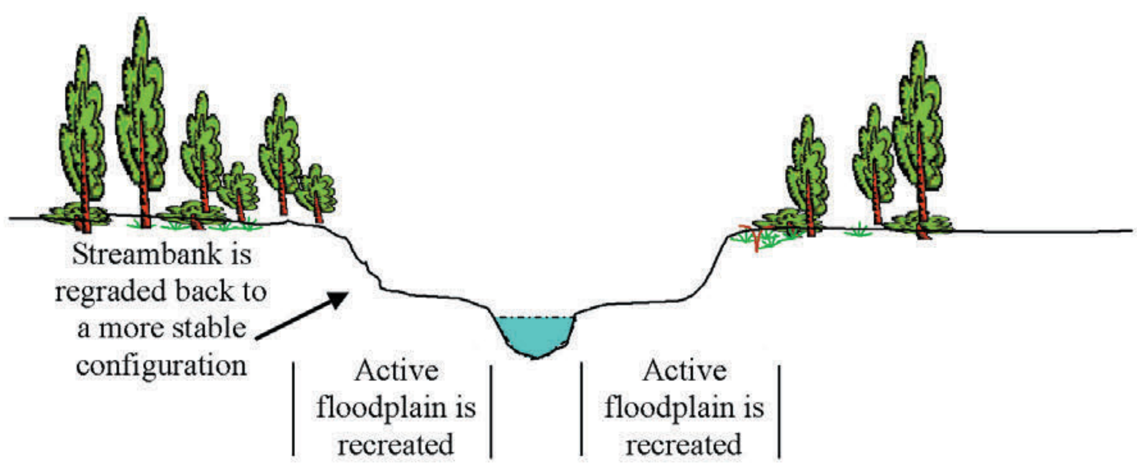


FIGURE 5: THE SAME STREAM CHANNEL AS FIGURE 4, BUT STREAM BANKS HAVE BEEN REGRADES TO CREATE TERRACES WHERE VEGETATION CAN BE PLANTED

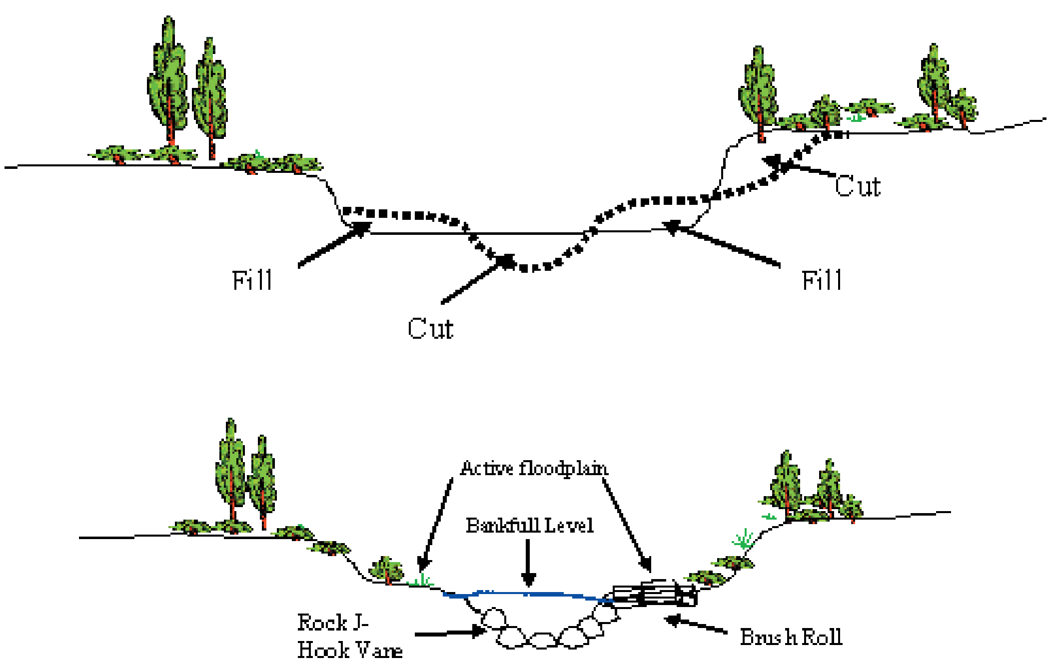


HOW TO CREATE A MODIFIED FLOODPLAIN IN BROAD FLAT STRETCHES WITH SEDIMENT DEPOSITION

In some cases, a stream may have experienced heavy sediment deposition over the years. In contrast to the deeply incised channels, with heavy sediment deposition tend to be wide, shallow and rather straight. Although there may have been fish present at one time, the shallow flows make it difficult for them to return. Where there is room, it is important to restore the nature meanders if possible.

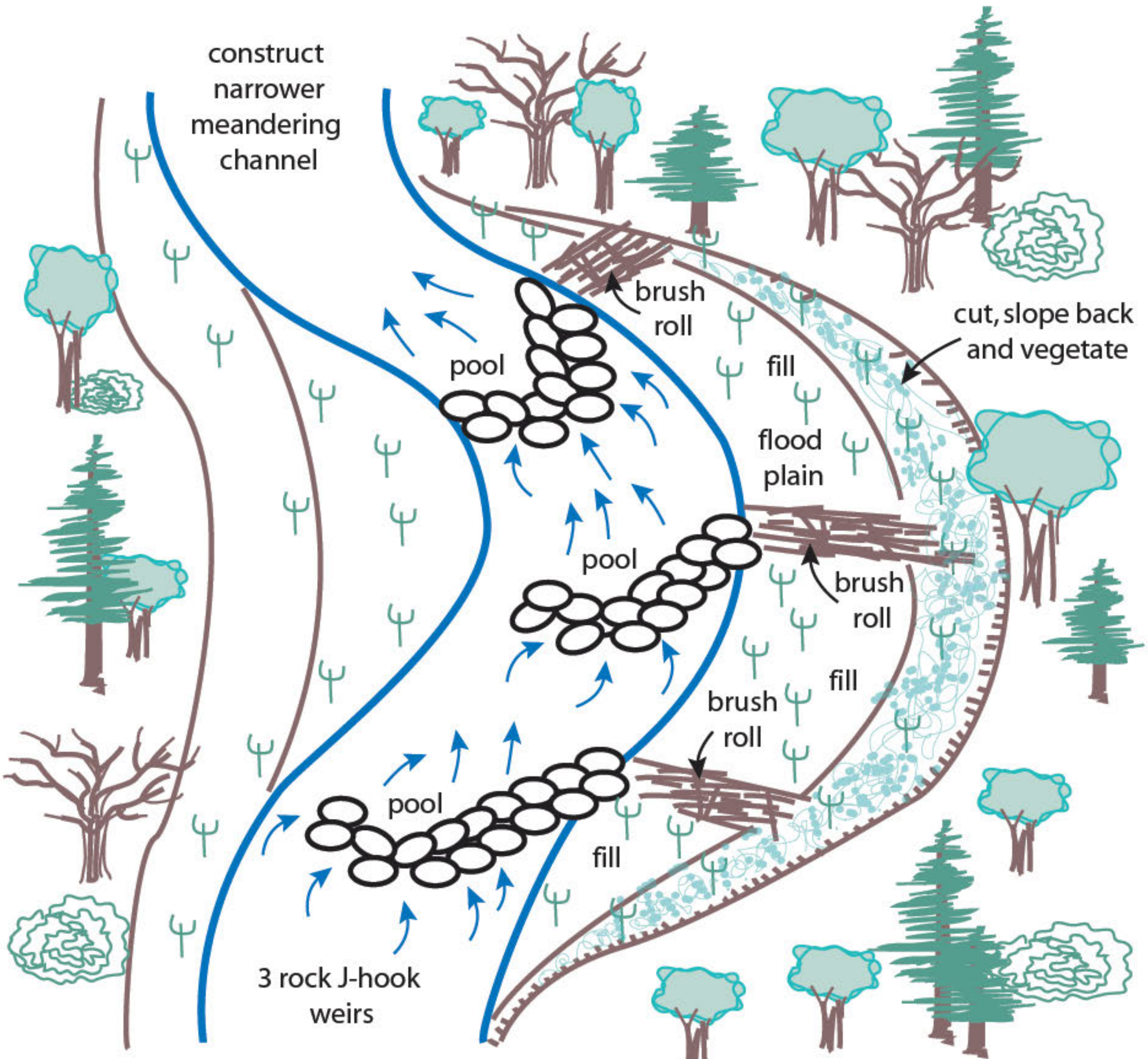
Figures 6 below shows a stream prior to a stream restoration project. As you can see, the channel was wide, shallow and rather straight. The bottom drawing shows that the channel was made narrower and constructed with a proper width/depth ratio at the bankfull level. This helped assure the proper transport of sediment through the area by increasing velocities in the active channel. The active channel was moved away from the right bank and into the center of the channel corridor, creating deep pools for steelhead trout and salmon. Brush rolls were used on the top of the right floodplain to accumulate fine sediment and the right vertical stream bank was sloped back and vegetated.

FIGURES 6: STREAM CHANNEL CROSS SECTION VIEW



POSSIBLE VARIATIONS ON THE FLOODPLAIN APPROACH: RESTORING NATURAL STREAM MEANDERS

Where there is sufficient room in the stream channel, it can be very helpful to modify the channel in a way that restores natural stream meanders. The diagram below shows how a creek channel can be narrowed and reformed with more meander. As noted earlier, a proper width/depth ratio at the bankfull level is created and a modified floodplain can be constructed. In this example, three J-Hook rock structures were installed with brush rolls on the right bank floodplain to divert the water away from the bank and into the center of the channel.



ADDITIONAL TOE AND BANK PROTECTION FOR HIGH FLOW VELOCITIES OR CONFINED AREAS

In the uncommon situations where water velocities are especially high, or where a structure is threatened by its proximity to the bank, additional protection or a hybrid approach may be desired. Placement of rock boulders at the toe of the slope, along with placement of riparian branch cuttings such as willows into the spaces between the boulders into the soil or earth-filled mats can accomplish this goal. Another hybrid approach is to use cellular confinement or rock on the lower slope, and the upper slope can be graded back to a less steep slope and revegetated The rock must be keyed into the streambed to prevent undercutting and failure of the rock slope protection.

In the cases noted above, the use of bank armoring is likely to cause more problems than it will solve, because it will not address the root cause of the problem. Instead, efforts should be made to reduce the water's velocity, or redirect it away from the bank using j-hook weirs or vanes.

USE OF GRADE CONTROL STRUCTURES

While efforts should be made to construct floodplains/flood benches and to consider hybrid alternatives, it is also important to consider whether a project should be addressed using a grade control structure. For example, sometimes bank erosion is a result of channel bed incision, which increases the height of a bank and reduces vertical support. If a channel is highly incised, simply regrading the slope may not be sufficient in the long-term, and the project will need to address grade control in order to stabilize the bank effectively. A variety of structures can be used, such as log or rock weirs, Newberry weirs, and vanes, in order to encourage sediment deposition and stabilization of the bed.

USE OF DEFLECTORS

Finally, in some cases it may be most appropriate to use smaller structures designed to

redirect high velocity flow away from eroding banks and into the center of the channel. Examples include spurs, kickers, deflectors, vane dikes, etc., and they should be considered as a way to train flows and reduce the amount of engineered bank protection. The photographs below provide some guidance on how and when these devices can be used. Detailed guidance of these methods, however, is beyond the scope of this Design Guide but should be considered by the design professional.

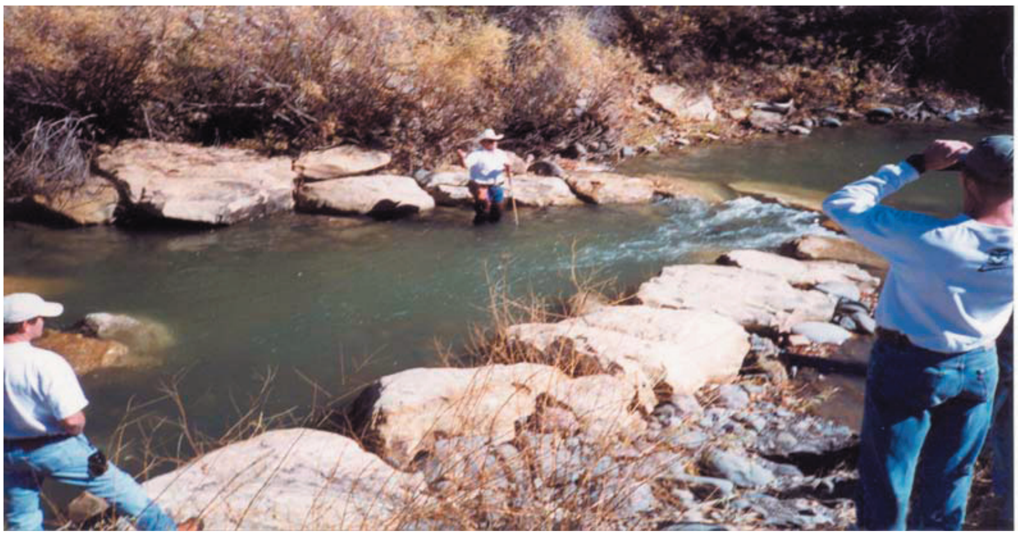
For a rock cross vane structure, boulders are placed in an upside down "V" shaped structure in the stream. This "V" shaped design serves to slow water velocities near the banks and direct the flow toward the center of the stream. The banks then become depositional areas, instead of erosion areas. At the same time, the increased velocities in the center of the channel actually increase the channel's flow and sediment transport capacity, reducing the risk for infrastructure flooding during high flow events. Finally, the rocks in the center serve as a channel grade control. The drop-off just downstream of the rocks creates a deep hole, which slows flows and can provide an excellent fish hold and hide habitat even at very low flows.

The rock J-hook structure is used to protect one side of the river bank by directing flows from that side to the center of the stream. As with the rock cross vane structure, the increased velocities in the center of the channel increase the channel's flow and sediment transport capacity and the deep hole is created for fish habitat.

ADDITIONAL TOE AND BANK PROTECTION FOR HIGH FLOW VELOCITIES OR CONFINED AREAS

In the uncommon situations where water velocities are especially high, or where astructure is threatened by its proximity to the bank, additional protection or a hybrid approach may be desired.

PHOTOGRAPH 1: ROCK CROSS VANE STRUCTURE:

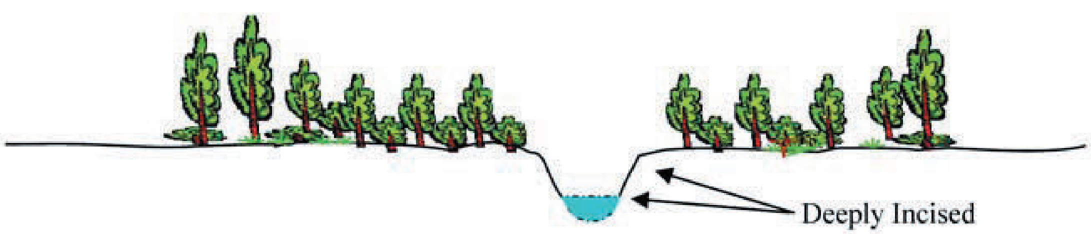


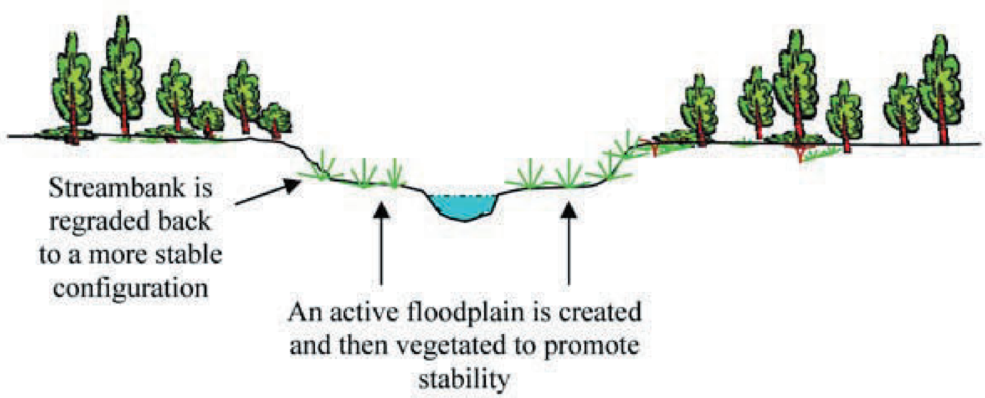
PHOTOGRAPH 2: ROCK J-HOOK STRUCTURE:

HOW TO CREATE A MODIFIED FLOODPLAIN IN BROAD FLAT STRETCHES WITH SEDIMENT DEPOSITION

In some cases, a stream may have experienced heavy sediment deposition over the years. In contrast to the deeply incised channels, channels with heavy sediment deposition tend to be wide, shallow and rather straight. Although there may have been fish present at one time, the shallow flows make it difficult for them to return. Where there is room, it is important to restore the nature meanders if possible.

Figures 6a and 6b below show a stream prior to a stream restoration project. As you can see, the channel was wide, shallow and rather straight. The bottom drawing shows that the channel was made narrower and constructed with a proper width/depth ratio at the bankfull level. This helped assure the proper transport of sediment through the area by increasing velocities in the active channel. The active channel was moved away from the right bank and into the center of the channel corridor, creating deep pools for steelhead trout and salmon. Brush rolls were used on the top of the right floodplain to accumulate fine sediment and the right vertical stream bank was sloped back and vegetated.





#2: SLOPE GRADING WITH VEGETATION AND FLOODPLAIN TERRACES SPACE PERMITTING

This is perhaps the least engineered, and often most effective, method of long-term bank repair, because it restores the natural contour and vegetative cover of the stream bank. If the bank is undercut or has slumped to a vertical face, consider matching the grade of a nearby stable slope. Usually a 2 horizontal to 1 vertical slope is considered stable for many soil types, and if space allows, a 3to 1 slope would be even better. Regrading the channel to create terraced banks (as described in Section 4) in order to include an active channel and floodplain area is appropriate wherever a more holistic approach to stream restoration is possible. As noted earlier, the stream bank should always be revegetated with appropriate native plants.

FIGURE 9A: SLOPE GRADING WITH VEGETATION

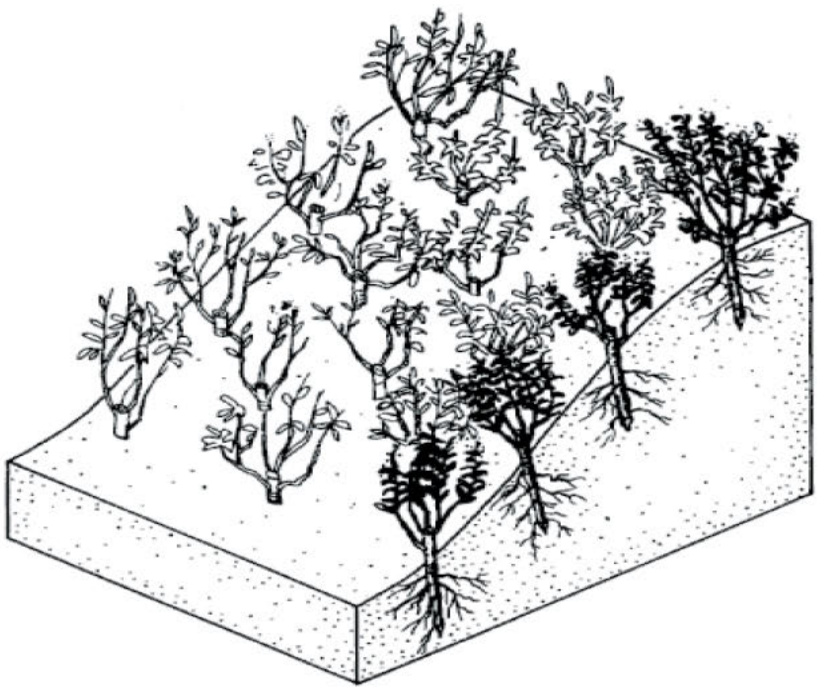
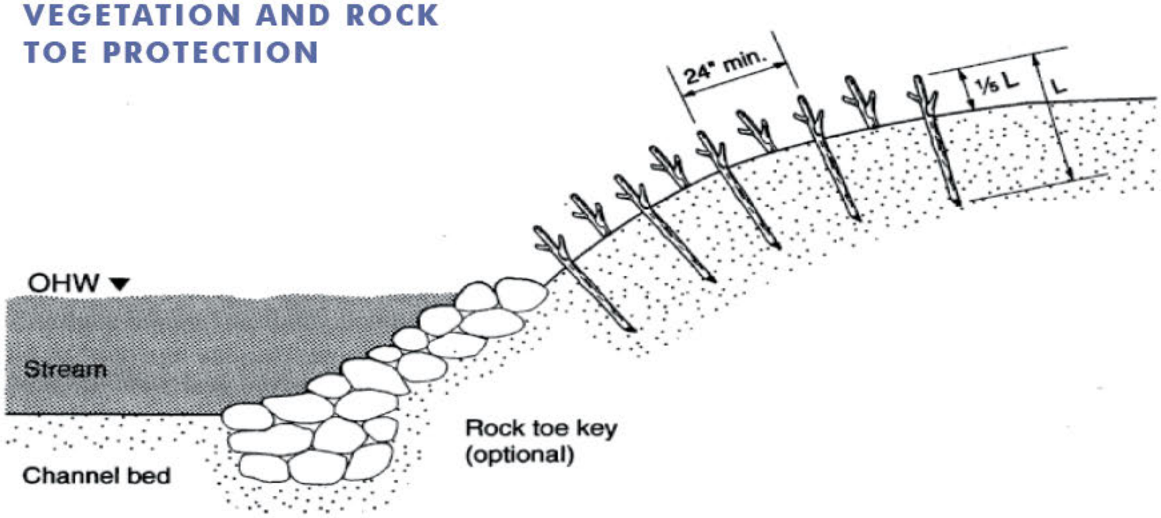


FIGURE 9B: CROSS SECTION OF SLOPE GRADING WITH VEGETATION AND ROCK TOE PROTECTION



#3: EROSION MATS

This method consists of securing geotextile blankets made of biodegradable materials like jute or coconut fiber to channel banks using stakes or staples. Biodegradable fabrics are preferable to plastic because they do not inhibit plant growth, or act like a net if they are dislodged during a storm. The erosion mats provide soft armor protection against erosive forces and are combined with live staking and direct seeding. Abrasive sediment, debris, foot traffic, and sunlight will slowly wear, snag, and tear these fabrics, potentially undermining the structure. That's why erosion mats are intended to be only the foundation of a vegetated erosion control system. In other words, the establishment of vegetation is crucial to the long-term success of erosion mats.

DESIGN CONSIDERATIONS:

- Toe protection may be required where significant toe scour is anticipated.
- The bank must be smooth before installing blankets to ensure adequate contact and prevent subsurface erosion.
- The erosion mats must be installed according to manufacturer's instructions in order to prevent failure.

#3A: EROSION MATS WITH BOULDER OR LOG TOE PROTECTION

This method consists of grading the lower portion of the eroded slope at a maximum of 1.5:1. The upper portion of the slope is then graded at a minimum slope of 2:1 and smoothed to ensure that the whole erosion mat contacts the soil. Appropriately-sized boulders are placed at the toe of the rebuilt bank up to the bankfull discharge water elevation, or even slightly higher. Voids between the boulders can be planted using live stakes.

DESIGN CONSIDERATIONS:

- Best for bank slopes of 3:1 or steeper
- Boulders must be keyed in (min. 3 feet) at the toe of the bank.
- Boulder placement must not constrict the channel cross section or reduce the width-to-depth ratio. Otherwise, the repair will likely destabilize the channel.
- The placement of boulders or armoring along the bank may increase turbulence in the area and other areas downstream. This could increase erosion.

#4: CONTOUR WATTLING (FASCINES)

This method consists of tying long bundles of plant cuttings (typically willows or cottonwood) together with twine and anchoring them in shallow trenches, parallel to the stream, with wooden stakes. When the cuttings develop root systems and mature, the plants provide structural soil stability. This technique is generally used to manage surface erosion. It works well in straight stream sections and wherever flow velocity is low.

DESIGN CONSIDERATIONS:

- The long bundles trap and hold soil on banks by creating small, dam-like structures, effectively segmenting the slope length into a series of shorter slope lengths.
- This method enhances the opportunities for locally native species to colonize and therefore should, where appropriate, be used with other soil bioengineering systems and live plantings.
- Reinforcement at the toe of bank may be a limiting factor.
- Contour wattling does not work well in locations where slopes are undergoing geotechnical failure.

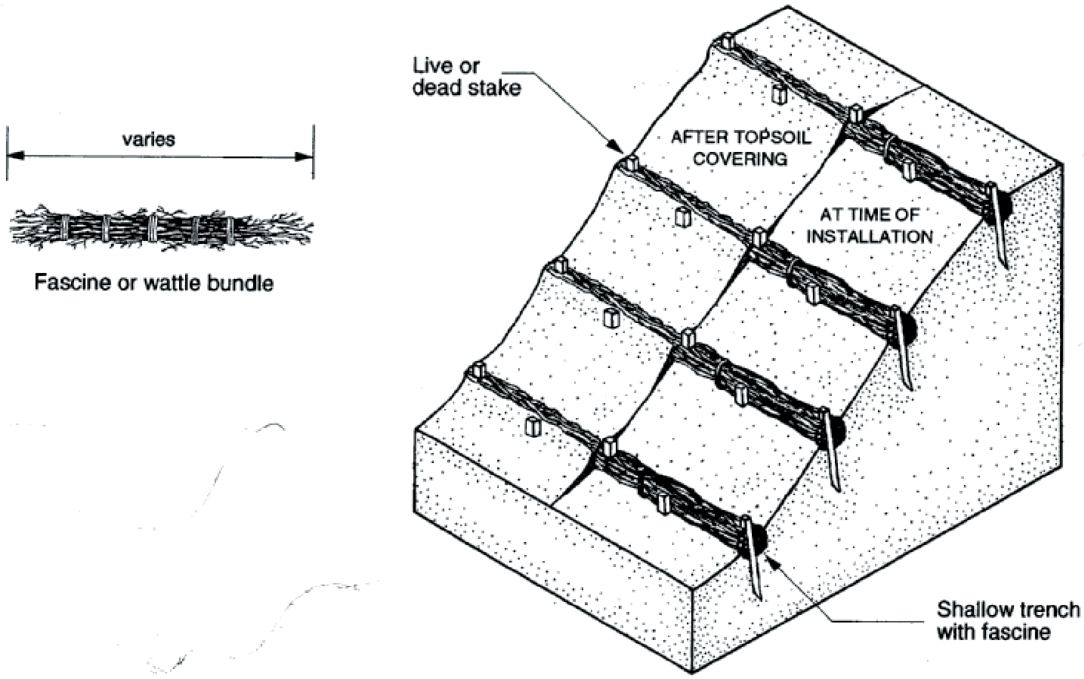
#4A: CONTOUR WATTLING WITH BOULDER OR LOG TOE PROTECTION

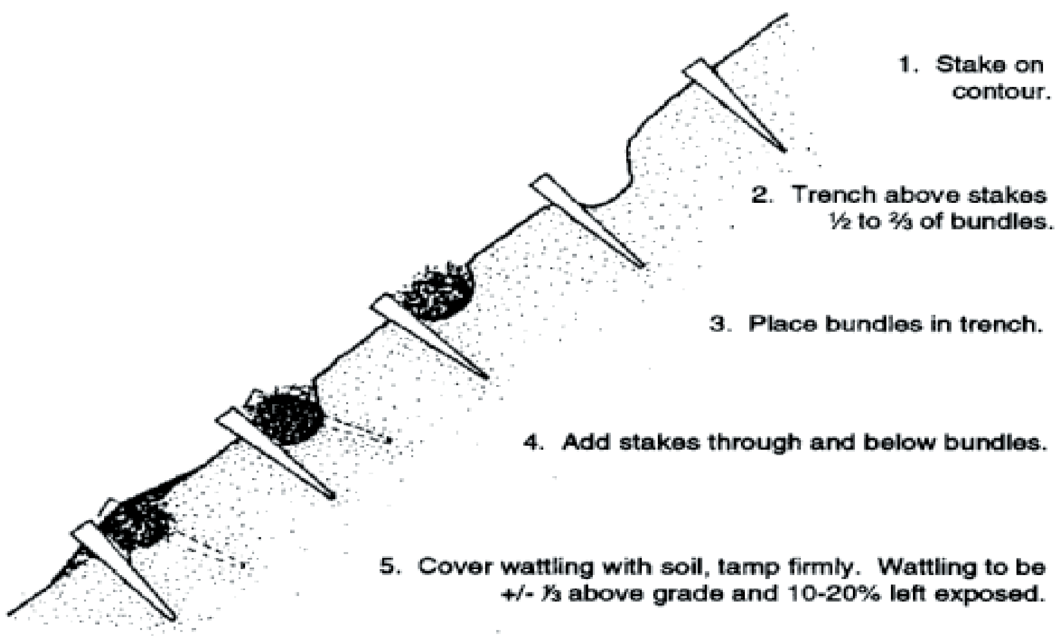
Appropriately-sized boulders are placed at the toe of the rebuilt bank up to the bankfull discharge water elevation or slightly higher. Voids between the boulders can be planted using live stakes.

DESIGN CONSIDERATIONS:

- Boulder placement must not constrict the channel cross-section or reduce the width-to-depth ratio. Otherwise, the repair will ` likely destabilize the channel.
- The placement of boulders or armoring along the bank may increase turbulence in the area and other areas downstream, which could increase erosion.

FIGURE 10: CONTOUR WATTLING





#5: BRUSH MATTRESS

First, the bank must be prepared. The eroded slope is graded and smoothed to ensure that all willows are in contact with the soil. Then, a deep trench (2 ft. min) is dug at the toe of the bank for the butt ends of the willow branches. Wood, steel, or live willow stakes are partially driven into the soil in rows, on three foot centers, in the area that will be covered by the mattress. After the stakes have been placed, live willow branches are put on the bank with their butt ends in the trench. Straight branches no shorter than four-feet in length and .5 to 1" in diameter are used. If the branches are not long enough to reach the upper end of mattress, several laye rs may be used; however, it is necessary to "shingle" the layers by lapping each new layer over the one below by at least 18".

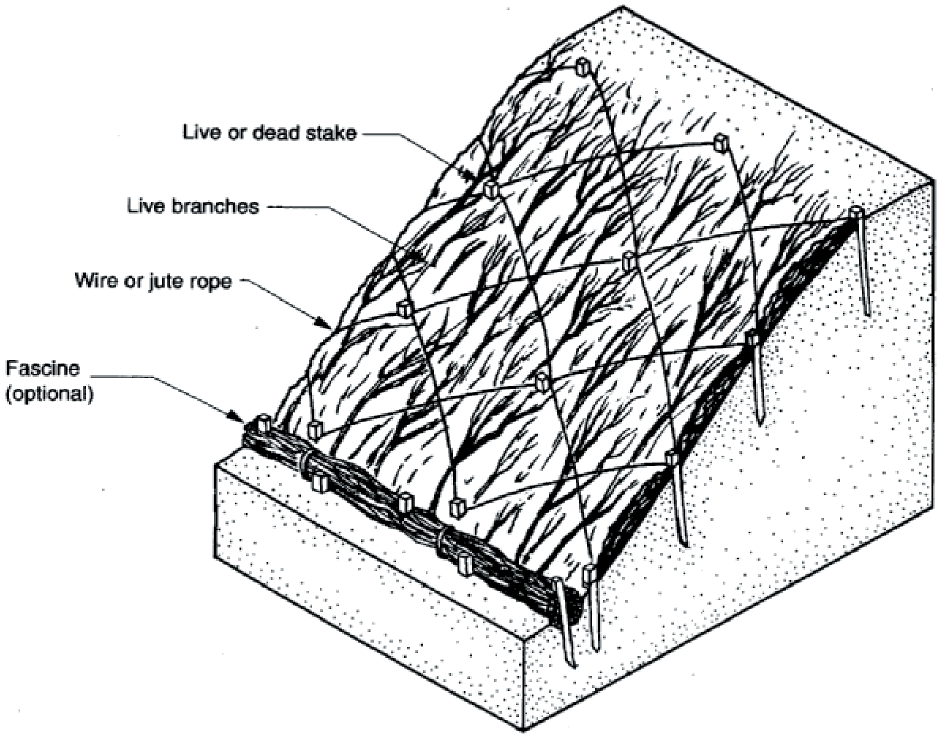
Once the bank is covered by a thick layer of willows, cross branches are placed horizontally over the bottom layer. These branches are placed against the stakes and then tied to the stakes using wire or string. The stakes are then driven into the bank at least two feet deep. After the completion of the mattress, the toe trench is filled with appropriately-sized boulders and rocks to anchor the butt ends of the branches. The brush mattress should be covered with an amount of soil sufficient to ensure a good contact surface between the mattress and the soil, leaving some buds and twigs exposed.

This method forms an immediate protective cover over the stream bank, captures sediment during flood flows, and rapidly restores riparian vegetation and streamside habitat. This measure is not appropriate where toe scour is anticipated, in which case boulders may need to be added at the toe.

DESIGN CONSTRAINTS AND CONSIDERATIONS:

- Branches should be tamped down before tying to create a good contact surface between the soil and the mattress.
- Butt or basal ends of branches must be covered with soil so they can root and to prevent them from drying out.
- Branches should be partially covered with soil.
- **This method should not be used on slopes that are experiencing geotechnical failures or other slope instability.**

FIGURE 11: BRUSH MATRESS



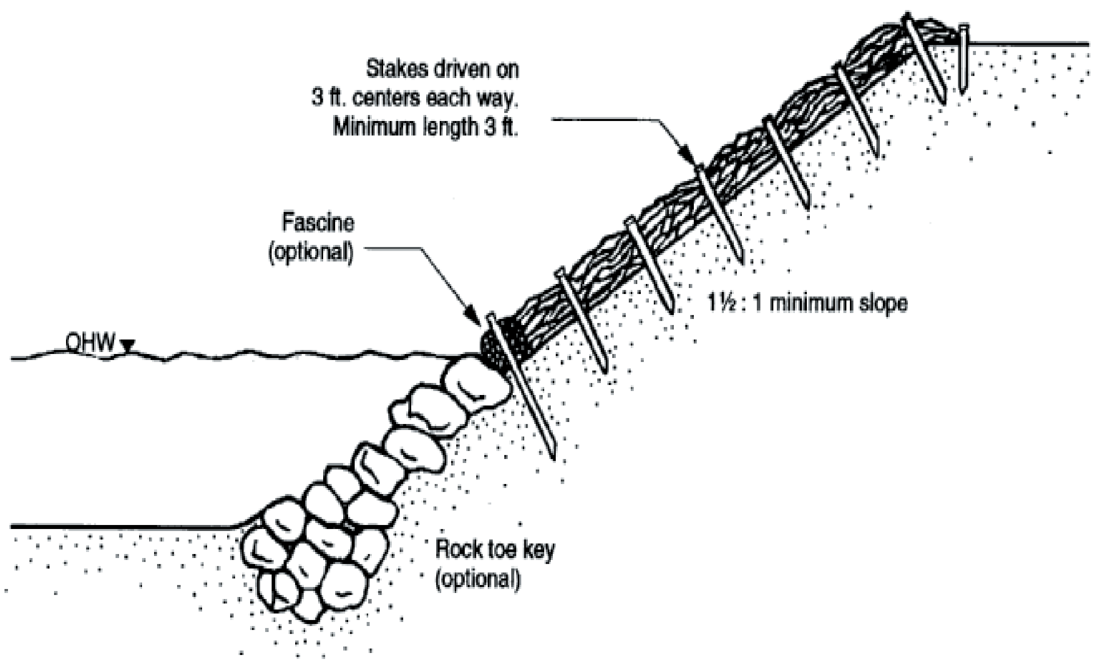
#5A: BRUSH MATTRESS WITH BOULDER OR LOG TOE PROTECTION

First, the lower portion of the eroded slope is graded at a maximum slope of 1.5:1. Then the upper portion of the slope is graded at a minimum of 2:1 and smoothed to ensure all willows are in contact with soil. Appropriately-sized boulders are placed at the toe of the rebuilt bank, up to the bankfull discharge water elevation or even slightly higher. Live stakes can be placed between the boulders to establish vegetation. This method requires a lot of branches. Therefore, needs to be installed during low flow conditions so that growth can be established. Otherwise, the branches will wash away.

DESIGN CRITERIA:

- Boulders must be keyed in (min. 3 feet) at toe of bank.
- Boulders placement must not constrict the channel cross-section or reduce the width-to-depth ratio. Otherwise, the repair will likely destabilize the channel.
- The placement of boulders or armoring along the bank will increase turbulence in the area and downstream, which could cause increased erosion.

FIGURE 12: BRUSH MATTRESS WITH BOULDER OR LOG TOE PROTECTION



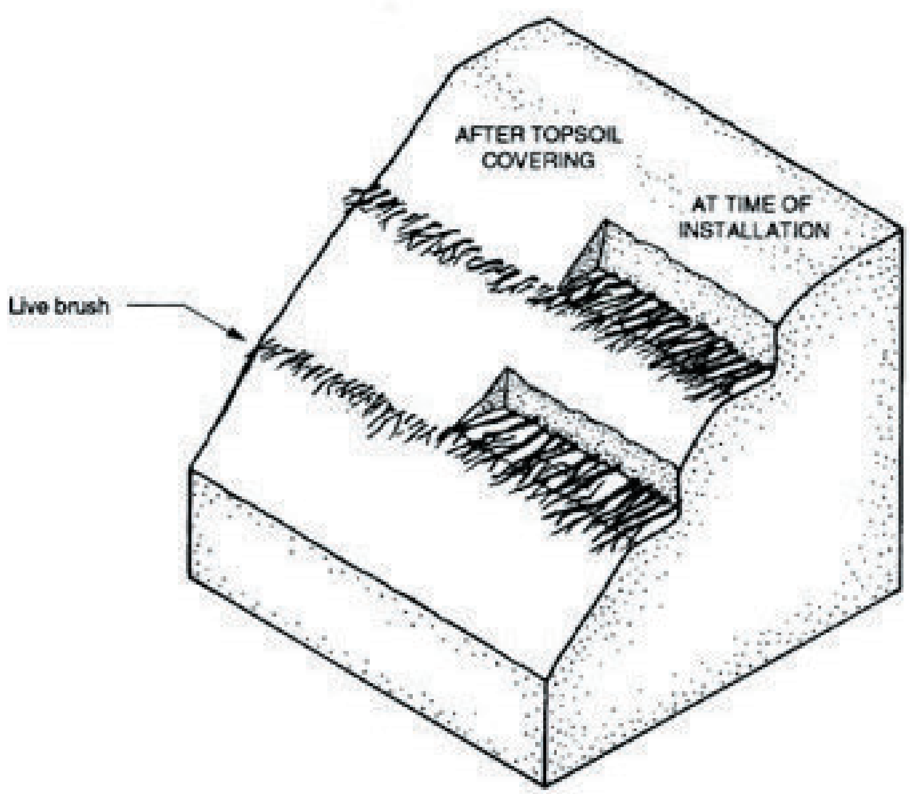
#6: BRUSH LAYERING

In this method, alternating layers of soil and live branches are installed in horizontal rows on the streambank. This method is more substantial than brush mattresses and can be used to repair erosion gullies, scour holes, and other significantly scoured areas. The buried branches take root to reinforce the substrate, while the tips produce vegetative top growth that protects the bank surface. This method can also be used in combination with a rock toe, vegetated geogrid or live cribwall as described later in this section.

DESIGN CONSTRAINTS AND CONSIDERATIONS:

- Installation is best done during dry periods or low flow conditions since construction requires earthwork.
- A large amount of branches are needed for this method.

FIGURE 13 : BRUSH LAYERING



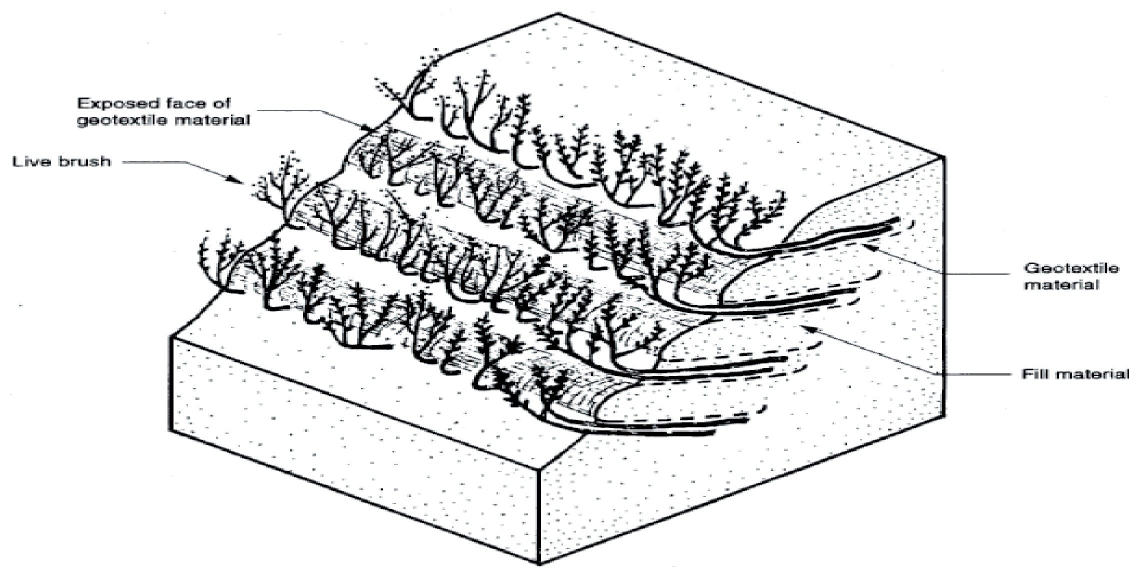
#7: VEGETATED GEOGRIDS OR SOIL LIFTS

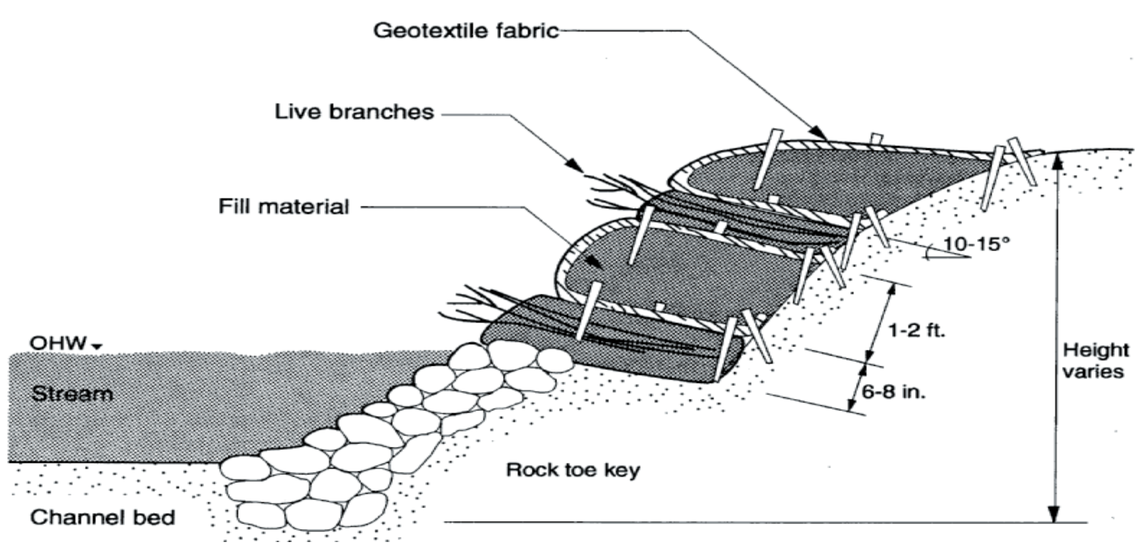
This method is similar to brush layering, but adds even more stability by wrapping engineered soil lifts in biodegradable erosion control fabric or geotextiles between layers of live branches. This method is useful where site constraints don't allow the slope to be laid back. Boulder or log toe-protection can also be incorporated into the design where site conditions warrant.

DESIGN CONSIDERATIONS:

- Boulder placement must not constrict the channel cross-section or reduce the width-to-depth ratio. Otherwise, the repair will likely destabilize the channel.
- Armoring or the placement of boulders along the bank will increase turbulence in the area andother areas downstream, which could increase erosion.

FIGURE 14: VEGETATED GEOGRIDS OR SOIL LIFTS





#8: ROOT WADS AND BOULDERS

This method consists of using a combination of boulders, logs, and live plant material to armor a stream bank. It enhances fish habitat, and creates a natural-looking bank stabilization structure [1]. Footer logs are set in a toe trench below the thalweg line (the line of maximum depth in a stream), with the channel end pointed downstream and the butt end angled 45 to 60 degrees upstream. A second log (with a root wad) is set on top of the footer log diagonally, forming an "X".

The root wad end is set pointing upstream and the butt end lying downstream 45 to 60 degrees. The apex of the logs are anchored together using boulders, re-bar or cables. Large boulders are placed on top and between the logs at each apex. After all the logs and boulders are set in place, live plant material, such as willows, is placed within the spaces of the structure behind the boulders. Excavated gravel and stream materials can then be placed over the bank end portion of the structure1.

This method will tolerate high boundary shear stresses if logs and root wads are well anchored. This method should, where appropriate, be used in conjunction with soil bioengineering or live vegetation plantings in order to stabilize the upper bank and ensure a regenerative source of streambank vegetation. The endurance of the structure depends on the species of logs used; it might need replacement if vegetative colonization does not take place.

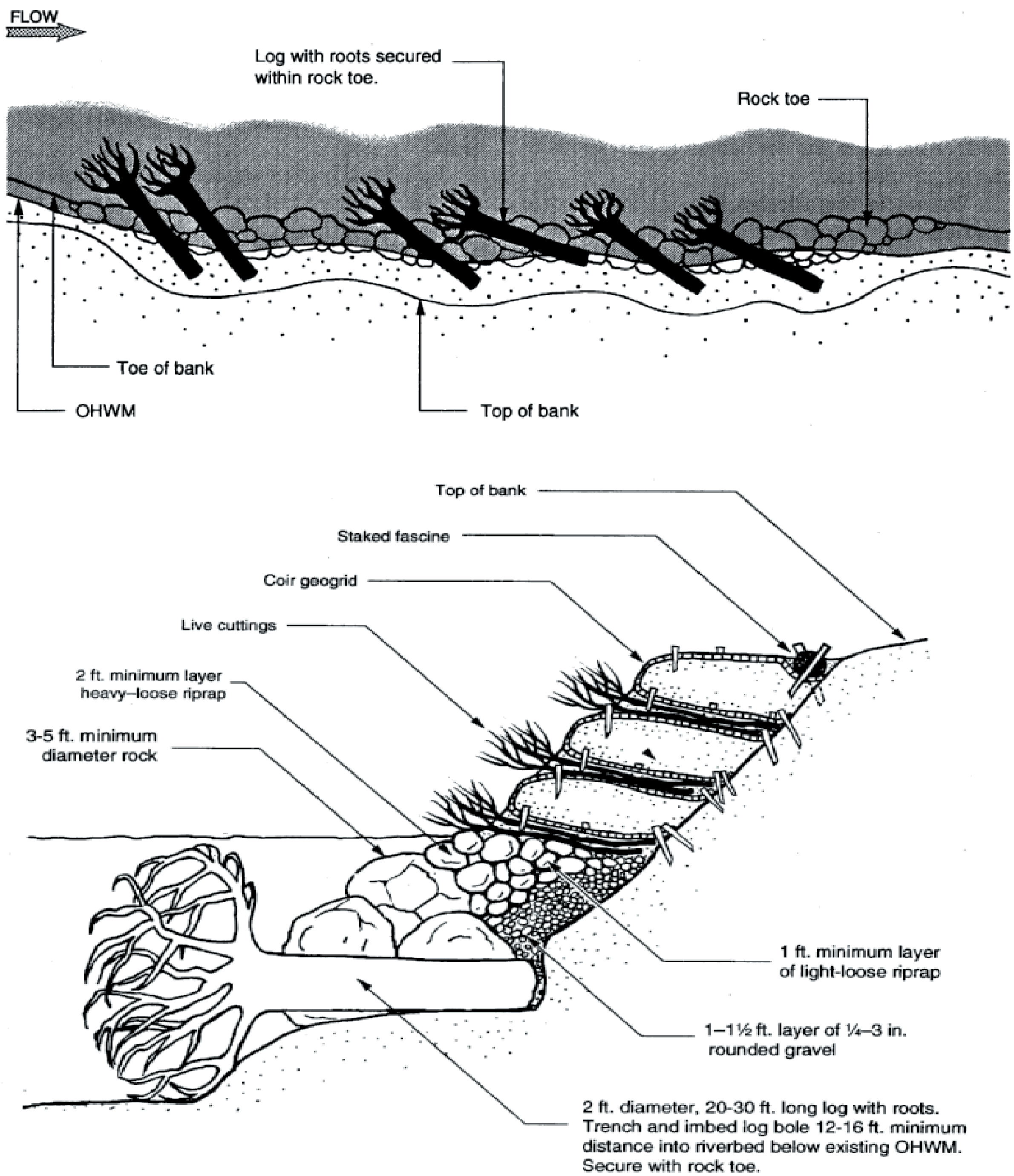
DESIGN CONSIDERATIONS:

- This method may cause channel scour and erosion of downstream and opposite banks if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour. [2].

[1] Source: California Department of Fish and Game, California Salmonid Stream Habitat Restoration Manual

[2] Source: Natural Resources Conservation Service, Stream Corridor Restoration Principles, Processes and Practices

FIGURE 15: ROOT WATDS AND BOULDERS



#9: BOULDER/ROCK REVETMENT

Rock rip-rap is a method for armoring stream banks with boulders that prevent bank erosion. Rock riprap can be used at the toe of the slope in combination with other vegetative methods on the upper portions of the bank. Rock can also be used for drainage outfall structures. Rip-rap footing is laid in a toe trench dug along the base of the bank. The size of the rock is determined according to the expected velocity in the channel, and can vary from 6" to 18" for velocities up to 10 feet per second up to 24" minimum for higher velocities. Large angular boulders are best suited for this purpose because they tend to interlock. The rock's specifications must meet certain standards in order to assure that it is structurally sound.

A gravel blanket that is at least one foot thick should be placed under the rock rip-rap on slopes of 1:1 or greater. This prevents underlying soil from being washed out, which leads to slope slump and failure during periods of high flow. Geotextile fabrics should be avoided, since they prevent the natural establishment of vegetation[1].

This method should, where appropriate, be used with soil-bioengineering systems, or live vegetation, to stabilize the upper bank and ensure a regenerative source of streambank vegetation. A major benefit of this method is that the components are flexible and their function is not impaired by slight movement from settlement or other adjustments[2].

DESIGN CRITERIA AND CONSIDERATIONS:

- Rock should be keyed in approximately three feet below the bed elevation.
- Rock can be graded from larger at the toe to smaller at the upper banks.
- This method may cause channel scour and erosion, especially downstream and along opposite banks, if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour.

#9A: BOULDER REVETMENT WITH SOIL AND REVEGETATION

This method consists of placing soil over the boulders and installing vegetation by staking and/or direct seeding. Biodegradable erosion control mats are placed over the soil to help control erosion until vegetation establishes itself. Special care must be taken while driving live stakes between boulders to avoid damage to the cambium layer of the woody material and to ensure good soil/water/stake contact. Thick rip-rap layers may require special tools for establishing staking pilot holes.[2]

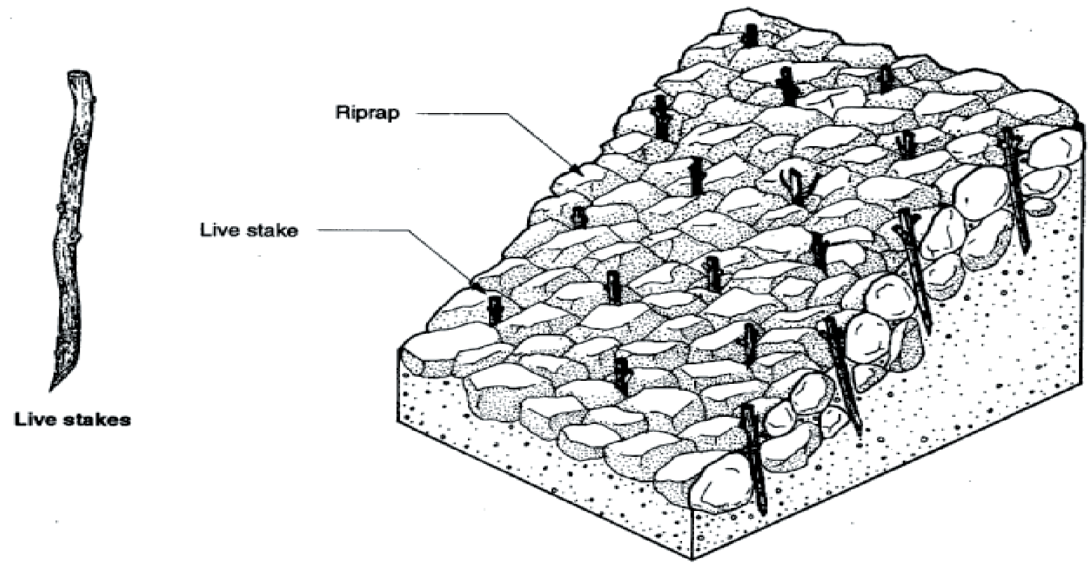
DESIGN CONSIDERATIONS:

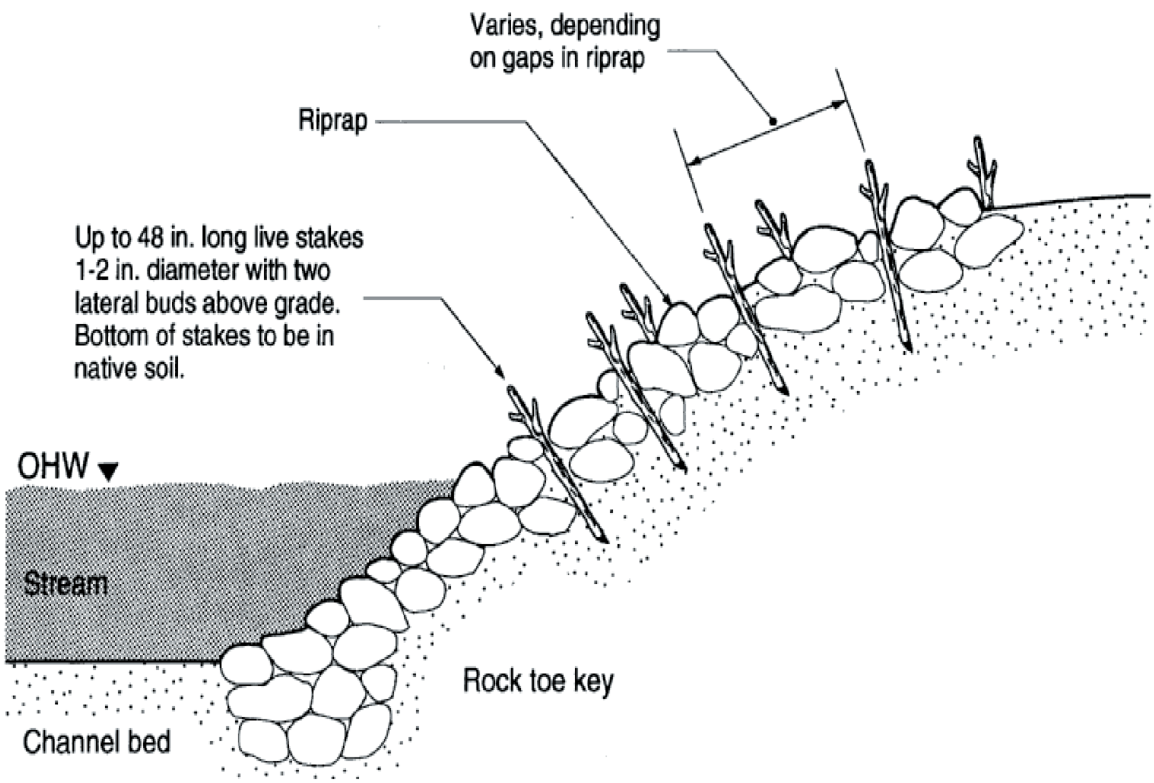
- Woody material can be placed using a backhoe with an auger attachment, or by driving a steel bar between boulders, or by placing rock around durable planting tubes.
- This method may cause channel scour and erosion of downstream and opposite banks if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour.

[1] Source: California Department of Fish and Game, California Salmonid Stream Habitat Restoration Manual

[2] Source: Natural Resources Conservation Service, Stream Corridor Restoration Principles, Processes and Practices

FIGURE 16: BOULDER REVETMENT WITH SOIL AND REVEGETATION





#10: CELLULAR CONFINEMENT SYSTEM

Soil cellular confinement system (geocell) is a polyethylene plastic cellular system where structural strength is developed by the composite design of soil, plant roots, and the plastic's cellular configuration. This system is available in eight-inch deep honeycomb mats that can be installed in offset vertical layers to create terraced planting areas. The honeycomb cells are filled with soil, moderately compacted, and planted with woody vegetation and grasses. The structure functions similarly to a crib wall structure. This method can also be used in combination with slope grading and vegetation on the upper slopes.

This method can foster the development of vegetation.

#11: LIVE LOG CRIB WALLS

Live log crib walls are used to reduce sediment input and protect banks in areas where logs are available and boulders are not practical[1]. These temporary structures are designed to rot and degrade after live plant material has established itself. Cribbing provides protection in areas with near-vertical banks where bank sloping options are constrained by adjacent land uses.

In this method, two rows of base logs are placed parallel to the bank, in trenches below stream grade, to minimize undercutting of the structure. Tie-back logs are notched into the base logs and placed at regular intervals (typically 6 to 8 feet) along the base logs. Tie-back logs are attached to the base logs using re-bar pins or cables. There should be at least two tie-back logs connecting each pair of base logs. Once the first row of tie-back logs has been connected, a second set of face logs is placed on top of the tie-backs. This procedure is repeated until the desired level of bank protection is achieved. As each lift is constructed, the face logs and tie-backs are filled with a mix of gravel and cobbles to the top of the face log. It is not necessary to use topsoil in the fill material; but there should be sufficient fine-grain material to insure vegetation growth. Live cuttings are then laid in to form a complete cover layer. These live branches should be long enough to have their butt ends in the soil behind the crib wall. The tips should stick out of the crib wall no more than a quarter of the cutting total length. The branches are then covered with the gravel/ cobble mix to the top of the tie-backs, and the next layer is continued.

This method is effective on the outside of bends where high velocities are present, and in situations where a low wall may be required to stabilize the toe and reduce slope steepness[2]. The use of crib walls in a specific location must be considered carefully in the context of the stream's function. If placed incorrectly relative to the active channel, the bends in a meandering stream can induce considerable damage downstream or on the opposite bank. This method does not adjust to toe scour and should be used in combination with soil bioengineering systems and live plantings to stabilize the upper slopes2.

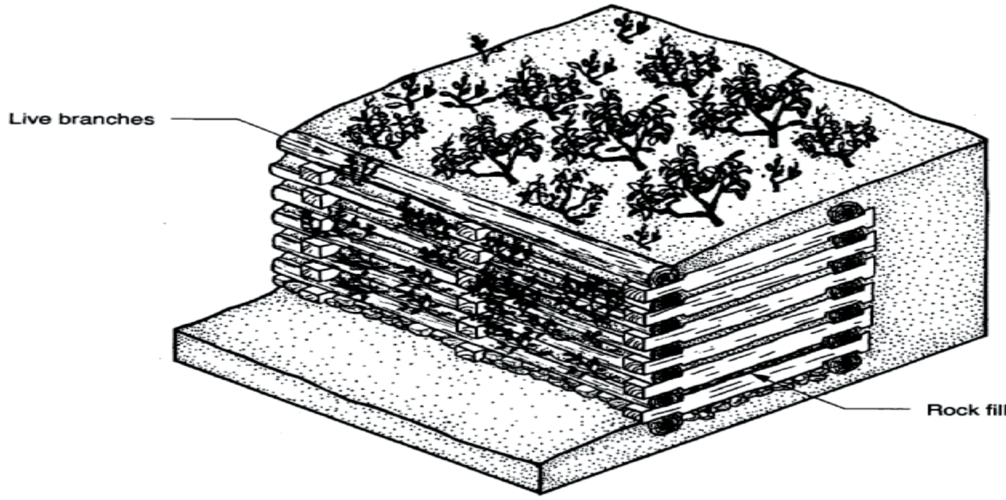
DESIGN CRITERIA AND CONSIDERATIONS:

- This method may cause channel scour and erosion of downstream and opposite banks if a modified floodplain is not constructed along the opposite bank. It may also cause upstream scour.
- As the logs rot, the crib wall can be undercut and eventually fail. If the structure fails, hazardous rebar and steel cable can be deposited in the river along with the logs and other debris of the structure.

[1]Source: California Department of Fish and Game, California Salmonid Stream Habitat Restoration Manual

[2] Source: Natural Resources Conservation Service, Stream Corridor Restoration Principles, Processes and Practices

FIGURE 17: LIVE LOG CRIB WALLS



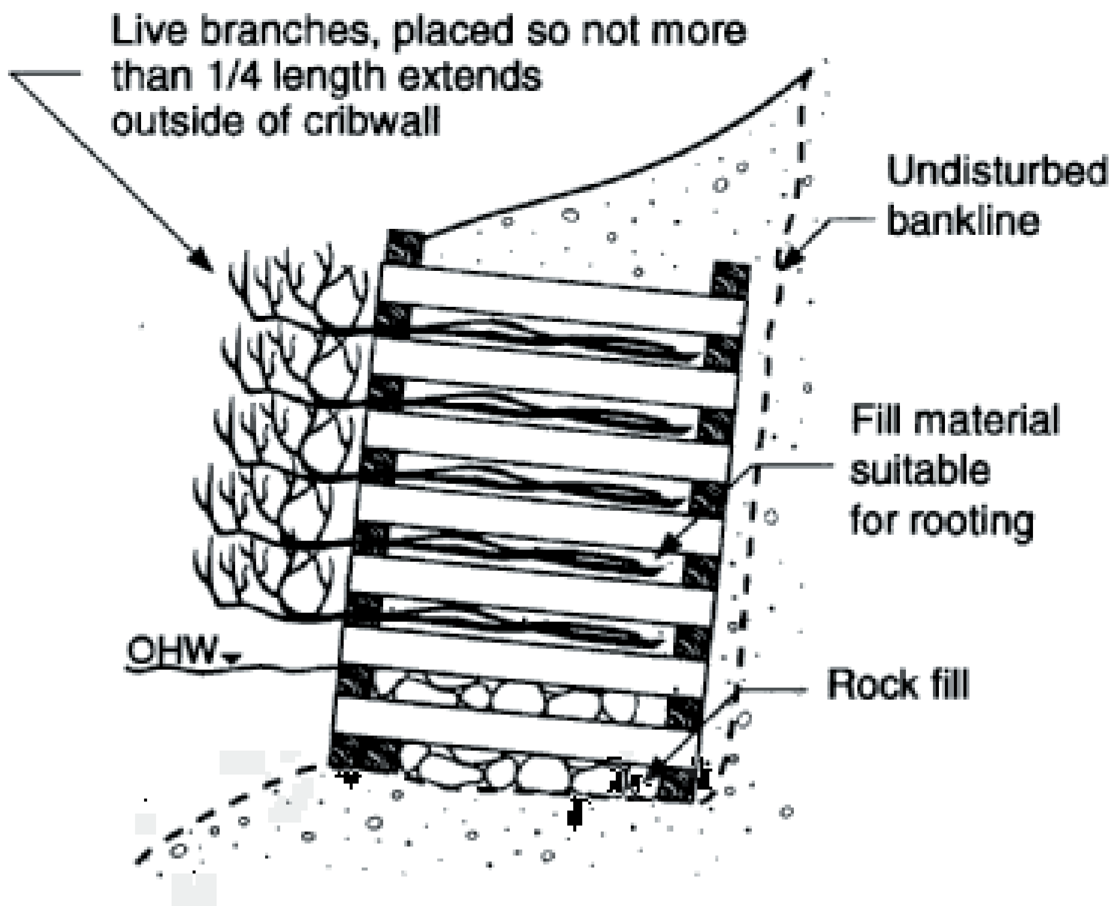


TABLE 2: EROSION REPAIR METHODS THAT ARE NOT RECOMMENDED:

Repair Method	Appropriate Slope	Appropriate Water Velocity	Environ Value	Cost
12 Concrete Crib Walls	Up to 0.25:1	High: up to 15 ft/sec; depending on size of crib wall openings.	Negative	High
13: Articulated Concrete Blocks	Up to 1:1	High: up to 15 ft/sec; for closed cell ACBs, low to medium for open cell ACBs.	Negative	High
14: Gabions	From 0.75:1 up to 3:1	High: up to 15 ft/sec; lower velocity if planted, depending on size and number of planting pockets.	Negative	High
15: Sacked Concrete	Up to 0.5:1	High: up to 15 ft/sec;	Negative	High
16: Gunite Slope Protection	Up to 1:1.	High: up to 15 ft/sec	Negative	Medium

#12: CONCRETE CRIB WALLS

Concrete crib walls consist of stacked interlocking concrete frames that form a retaining wall. Its structural strength is due in part to the composite design of a concrete frame with compacted backfill. Crib walls are constructed with open face panels that are planted by live staking. This method restricts plant growth to the size of the panel opening. As the crib wall slope is flattened and the lattice becomes more open, the vegetation potential increases, and the allowable velocity decreases because of the exposed soil and vegetation. Concrete crib walls perform similarly to live log crib walls. Because the crib wall is a rigid structure, it is more prone to massive failure in the event of undercutting or settlement.

All crib walls tend to cause channel bed and bank erosion both in the immediate area and other areas downstream, and may also cause erosion upstream. Most crib walls eventually fail because they attempt to resolve a symptom of erosion, not its cause. The use of concrete crib walls is discouraged. *This method is mentioned only for reference.*

13: ARTICULATED CONCRETE BLOCKS

Articulated concrete blocks (ACB) consists of concrete interlocking blocks that are cabled together to form mats that can be laid on the channel slope and/or channel bottom.

There are two styles of ACBs: open cell and closed cell. The open cell style allows for vegetation to be recruited into the soil filling each cell. Vegetation growth is restricted by the sizes of the cell openings and by the disconnection caused by the cell walls. In our arid climate, the long-term viability of vegetation within the restricted cell openings is problematic. However, open planting areas can also be constructed into the ACB mats by creating an opening in the mat by removing some of the blocks. The open areas can be revegetated with shrubs and trees. Irrigation is necessary to aid plant establishment.

This method will create channel and bank erosion both down and upstream of protected areas. It is environmentally unfriendly and prone to failure. When it fails, steel cables and stakes hazardously protrude from the mats into the channel. *This method is not appropriate for small erosion repair sites, and is discouraged because of the limited potential for biotic resources.*

#14: GABIONS

This method consists of placing large wire baskets filled with rocks on channel banks, either as mattresses or stacked in layers that resemble steps. Gabions can sometimes naturally revegetate if adequate water and soil are available. Gabions can also be revegetated using planting boxes. (Planting boxes are gabion cells that are left open to bare soil and revegetated with shrubs and trees.) Temporary irrigation may be provided to the planted vegetation in order to aid its establishment. But, wire baskets can deteriorate over time and may be harmful to fish.

Gabions are very hazardous and unfriendly to native fish, especially salmonids, which often try to spawn in gabions below the water line. The basket wire deteriorates quickly, and the fish are injured on the baskets' sharp wire barbs.

Furthermore, the baskets used to line or armor the banks of streams cause bed and bank erosion. They often undercut or fail due to slumping of the soil on which they are constructed. *The use of gabions is discouraged and are rarely permitted by the Department of Fish and Game except in extreme situations. The material is included here for information.*

#15: SACKED CONCRETE

Sacked concrete slope protection consists of burlap bags filled with concrete and placed against channel banks. Sacked concrete does not provide any revegetation potential. However, it offers the opportunity to contour walls around existing vegetation such as tree wells.

Sacked concrete should not be used because it causes erosion, degrades water quality, and destroys other beneficial uses. It is included here for reference. There may, however, be extreme circumstances where site constraints, vertical slopes, and high velocities preclude all other options.

#16: GUNITE SLOPE PROTECTION

Gunite slope protection consists of a pressurized concrete mixture sprayed over an eroded bank. The gunite can be textured, colored, and formed for aesthetics to mimic natural rock. Reinforcing steel may be placed against the bank prior to spraying. This is not an acceptable method of erosion repair, but is included here because it has been successfully used with soil nails to stabilize vertical slopes on upper banks where land use constraints preclude regrading of the slope. Sheet pile retaining walls have been used in a similar manner. Vegetation can be placed on the lower portions of the bank to enhance biotic resources.

Gunite slope protection causes erosion problems, degrades water quality and destroys other beneficial uses. *Therefore, the use of gunite slope protection is discouraged and is included here only for reference*.

SECTION 6 - OBTAINING PERMITS FOR STREAM-BANK REPAIR

(Taken from the Stream-Bank Repair Guidance Manual for the Private Landowner: Guadalupe and Alamitos Creeks)

PRACTICAL POINTS TO HELP YOU OBTAIN PERMITS FOR YOUR PROJECT

As noted earlier, if you are working in or around a creek or stream, you will likely need permits from a local, state, and/or federal agency. Below are some practical points to help you obtain permits for your project as quickly and efficiently as possible. Following this list is a matrix of activities and the agencies, which may require permits for those activities.

- **Learn the rules.** Familiarize yourself with applicable state, local, and federal agency permitting requirements. Determine which agencies may be involved in your project. Take time to study the protocols and regulations of these agencies. Refer to their web sites. Read staff reports, permit conditions, and studies relating to your project or similar projects.
- **Contact the agencies in charge of granting permits for your project.** You may need to obtain different permits for your project from a number of agencies. Contact the agencies that may need to issue a permit for your project to determine who will be involved. Ask about the agency's permitting process, obtain relevant forms, and discuss potential timelines for obtaining your permits. Do not expect to get schedule commitments at this stage, but at least get an idea of the how the process works and a feel for how long it may take.
- **Write a complete project description.** A complete project description is crucial. Include drawings, photographs and other supporting materials to assist the regulatory agencies in understanding what your project entails. Photographs and descriptions enable them to provide guidance and direction before a site visit can be scheduled.
- **Consult early and become familiar with agency staff.** Consultation with permitting and regulatory agencies should begin as early as possible. An in-person meeting is the best way to discuss your project. Try to have plans, maps, photographs of the project location, and other information available at the meeting. You can also request that a staff person meet you at the site.
- Reduce adverse environmental impacts. Design your project to eliminate or reduce as many potential health concerns and environmental impacts as possible. Consider environmentally superior alternatives described in the previous section. These methods are also generally easier and much faster to permit. Incorporate the suggestions you receive during early consultation. Employ a qualified design consultant with specialized expertise in stream analysis and design.
- **Pay attention to details.** Follow all the rules and listen to agency staff guidance. Respond promptly to requests for information. Be on time for meetings with representatives of the regulating agencies. Do not cut corners. Get in writing all dates, procedures, fees, etc..
- **Be willing to negotiate.** Recognize that government regulators may have a great deal of authority over your project, but that they are willing to negotiate. You should be, too.

- **When in doubt, ask.** If you are not sure whether your project needs a permit or whether it is regulated at all, ask. Going ahead without following the proper guidelines will ultimately cost you time, money, and goodwill.
- **Keep good records.** Keep notes of conversations and meetings. Ask for interpretations of rules to be written by the agency representatives. An easy way to do this is to confirm conversations by E-mail. Remember, agency staff time is limited; it is easier for them to review or comment on your understanding than for them to compose the correspondence.

PROHIBITED ACTIVITIES

Before you decide to do work near a creek or river, you should consider that it is illegal to place, store, or dispose of materials of any kind on the banks of, or into, a watercourse. Prohibited materials include dirt, soil, and concrete; pool and spa water; paints, solvents, and soaps; yard and animal waste; automobile and machinery fluids; and firewood and building materials. Remember to comply with best management practices that prevent pollution from entering the waterway and damaging the ecosystem.

AGENCIES THAT MAY REQUIRE PERMITS

Use this chart to help you determine which agency may be involved in your project. A checked box indicates that an agency may be involved and should be contacted, but does not mean they definitely will be involved.

	Santa Clara Valley Water District	Your City's Planning or Public Works Dept	NOAA	CalEPA DTSC	SWRCB Water Rights	Regional Water Quality Control Board	California Fish and Game	Army Corps of Engineers	U.S. Fish & Wildlife Service
Involve work on the bank of a river, stream, or lake?	X	X				X	X	X	X
Involve excavation of the bank?	X	X				X	X		
Involve placement of piers?	X		X	X		X	X	X	
stabilization or erosion control?	X	X				X	X	X	X
Require the removal of riparian or other wetland vegetation?	X	X	X			X	X	X	X
Involve planting riparian or wetland vegetation?	X		X			X	X	X	X
Affect native plants, wildlife, or fisheries?	X		X			X	X		X
Result in stormwater discharge into a creek or wetland?	X	X				X	X	X	X
Divert or obstruct the natural flow or change the natural bed or bank of a creek or wetland?	X	X				X	X	X	X
Involve repair, rehabilitation, or replacement of any structure or fill adjacent to a creek or wetland?	X	X				X	X	X	X
Involve placement of bank protection or stabilization structures or materials (e.g., gabions, riprap, concrete slurry/sacks)?	X	X				X	X		X
Involve building any structure adjacent to a creek or wetland?	X	X				X	X	X	X
Involve fish and wildlife enhancement, attraction, or harvesting devices and activities?	X					X	X	X	X

	Santa Clara Valley Water District	Your City's Planning or Public Works Dept	NOAA	CalEPA DTSC	SWRCB Water Rights	Regional Water Quality Control Board	California Fish and Game	Army Corps of Engineers	U.S. Fish & Wildlife Service
Use materials from a streambed (including but not limited to boulders, rocks, gravel, sand, and wood debris)?	X	X		X		X	X	X	X
Require the disposal or deposition of debris, waste, or any material containing crumbled, flaked, or ground pavement with a possibility that such material could pass into a creek or wetland?	X	X		X		X	X	X	X
Involve the removal of any materials from, or add fill to, a creek or wetland?	X	X	X	X		X	X	X	X
Involve grading or fill near a creek or wetland?	X	X	X			X	X		X
Involve a bridge or culvert?	X	X				X	X	X	X
Involve utility pipe lines?	X	X				X		X	
Involve a septic leach field near a creek or wetland?	X	X				X	X		
Require a water well near a creek or wetland?	X	X	X				X		
Involve work within historic or existing coastal wetlands?	X					X	X	X	X
Remove water from a creek for storage or direct use on non-riparian land?	X	X	X		X	X	X	X	X
Require that hazardous materials be generated and/or stored on site?	X	X		X		X			
Take place in, adjacent to, in a building adjacent to or near a river that has been designated as "wild and scenic" under state or federal law?	X					X	X	X	X

	Santa Clara Valley Water District	Your City's Planning or Public Works Dept	NOAA	CalEPA DTSC	SWRCB Water Rights	Regional Water Quality Control Board	California Fish and Game	Army Corps of Engineers	U.S. Fish & Wildlife Service
Require water to be diverted from a river, stream, or lake for the project or activity?	X	X			X	X	X	X	X
Affect water quality by the deposition of silt, an increase in water temperature, a change in the pH level, or in some other way?	X		X			X	X	X	X
Occur in an area where endangered or rare plant species are thought or known to occur?	X	X				X	X		X
Occur in an area where endangered or threatened fish, bird, or animal species are thought or known to occur?	X	X	X			X	X		X

SAN FRANCISCO BAY AREA JOINT AQUATIC RESOURCE PERMIT APPLICATION

As discussed earlier, projects in or near creeks and even intermittent streams can be regulated by many agencies, the local city government, local agencies, such as the Santa Clara Valley Water District, state agencies, such as the San Francisco Bay Regional Water Quality Control Board, and California Department of Fish and Game, and federal agencies, such as the Army Corps of Engineers and U.S. Fish and Wildlife Service, to name a few. For projects with an aquatic component, such as work near a creek or stream, a single application called the San Francisco Bay Area Joint Aquatic Resource Permit Application (JARPA) has been designed to replace individual applications for state, regional, and federal agencies. As suggested earlier, consider taking advantage of this consolidated application to streamline the project permit application process.

If a project requires local approval, such as that of the local city government or Santa Clara Valley Water District, be sure to check with these agencies about what to include in the application, since the JARPA document does not consider local agency requirements.

CALIFORNIA ENVIRONMENTAL QUALITY ACT

Prior to obtaining permits for a project, a California Environmental Quality Act (CEQA) review will be required if the project is undertaken by a public agency or if a public agency needs to issue a permit for a project. CEQA is found in Section 21000 et seq. of the Government Code, and the CEQA guidelines are found in Section 1500 et seq. of the California Code of Regulations.

The Guidelines have the force of law, and lay out the way CEQA is administered.

(See http://ceres.ca.gov/topic/env_law/ceqa/)

The purpose of the CEQA review is to inform project decision-makers of the issues associated with the project, to identify significant environmental impacts and reduce them, and to disclose to the public the rationale for the decision to approve a project. The agency responsible for the CEQA review is called the lead agency, and it is usually the agency with the most involvement in the project. The local municipality's planning department usually handles the CEQA review, however, CDFG is also a lead agency for purposes of issuing a Streambed Alteration Agreement.

Once the lead agency is identified, all other agencies that require a permit to be issued for the project, whether state or local, become responsible. Responsible and trustee agencies must consider the environmental document prepared by the lead agency and do not, except in rare instances, prepare their own environmental documents.

THERE ARE FOUR POSSIBLE SCENARIOS REGARDING CEQA REQUIREMENTS:

1. The project is exempt from CEQA. Exemptions are listed in the CEQA Guidelines. Specific rules should be consulted, but essentially, a categorical exemption cannot be used if the project has the potential for an individual or cumulative significant effect on the environment. Documentation of exemptions should be obtained from the lead agency. Unless a public hearing is required by the local agency for the project, a categorical exemption does not require a public hearing. The document is simply filed at the county for a specified period.

2. A Negative Declaration is issued by the lead agency for the project. A Negative Declaration can be issued if the project will have no significant impact on the environment without the need for mitigation measures to reduce a project impact to a less than significant level. A public hearing to adopt the findings and the Negative Declaration is required.

    Hint: If, at any time along the permitting or review process, you find that your proposed project can have a significant impact on the environment, and by redesigning your project, the impact can be eliminated or reduced to insignificant, you will save yourself time and money by redesigning your project.

3. A **Mitigated Negative Declaration** is issued for the project. This means that there are significant impacts from your project on the environment, but mitigation measures during implementation can be adopted to reduce these impacts to a less than significant level. A mitigation monitoring and reporting plan is required to identify, what, who, when and where for each mitigation measure, thus ensuring that all mitigation measures are implemented. A public hearing is required.

4. An **Environmental Impact Report** (EIR) is required to study the significant impacts of your project on the environment. Various alternatives to your project must be identified and evaluated and the environmentally preferred alternative must be selected unless there are overriding circumstances that make the project desirable, even though there are significant unmitigated impacts. This finding must be made by the approving body of the lead agency, along with the findings and MMRP. Because there are more alternatives to evaluate, there is a slightly longer review period and a requirement to specifically respond to comments. For this reason, an EIR can be the most time-consuming and complicated scenario.

SECTION 7 - REFERENCE MATERIALS

There is a wide body of literature that provides more detailed information on these bank protection repair techniques. We have identified several of the more comprehensive documents. A more complete list can be found at http://www.4sos.org/wssupport/ws_rest/rest_con.asp.

A CITIZEN'S STREAMBANK RESTORATION HANDBOOK

This 171 page handbook is a guide to restoring eroding streambanks using vegetation and flexible systems. It, features installation guidelines, sample budgets, case studies and tips on choosing the best restoration solution. $20 plus $5 shipping. To order call 800/284-4952 or E-mail sos@iwla.org.

HOW TO HOLD UP BANKS: USING ALL THE ASSETS

An informative, well-illustrated booklet on controlling stream erosion. Produced by the Boquet River Association (BRASS), a small nonprofit group with extensive experience in stream monitoring and restoration, the book helps citizen groups tap community resources and find success with low-cost techniques. Techniques covered include streambank shaping; grass, seedling, and live posts planting; log cribbing and stone riprap installation. To order send $8 to

BRASS, c/o Essex County Government Center, Box 217, Elizabethtown, NY 12932, or call 518/873-3688.

STREAM CORRIDOR RESTORATION: PRINCIPLES, PROCESSES, AND PRACTICES

Developed by an interdisciplinary team of stream and watershed management specialists, hydrologists, engineers and other EPA, federal agency, and private group representatives. A printed document is available for $71, a CD-ROM version sells for $60. Available through the Center for Watershed Protection. at http://www.cwp.org

THE PRACTICE OF WATERSHED PROTECTION: TECHNIQUES FOR PROTECTING AND RESTORING URBAN WATERSHEDS -- At $80, 150 articles are included on all aspects of watershed protection. Drawn from past issues of Watershed Protection Techniques as well as a wealth of other Center papers and reports, this 800-page book is organized around the eight tools of watershed protection, and indexed for easy reference. Available through the Center for Watershed Protection. at http://www.cwp.org.

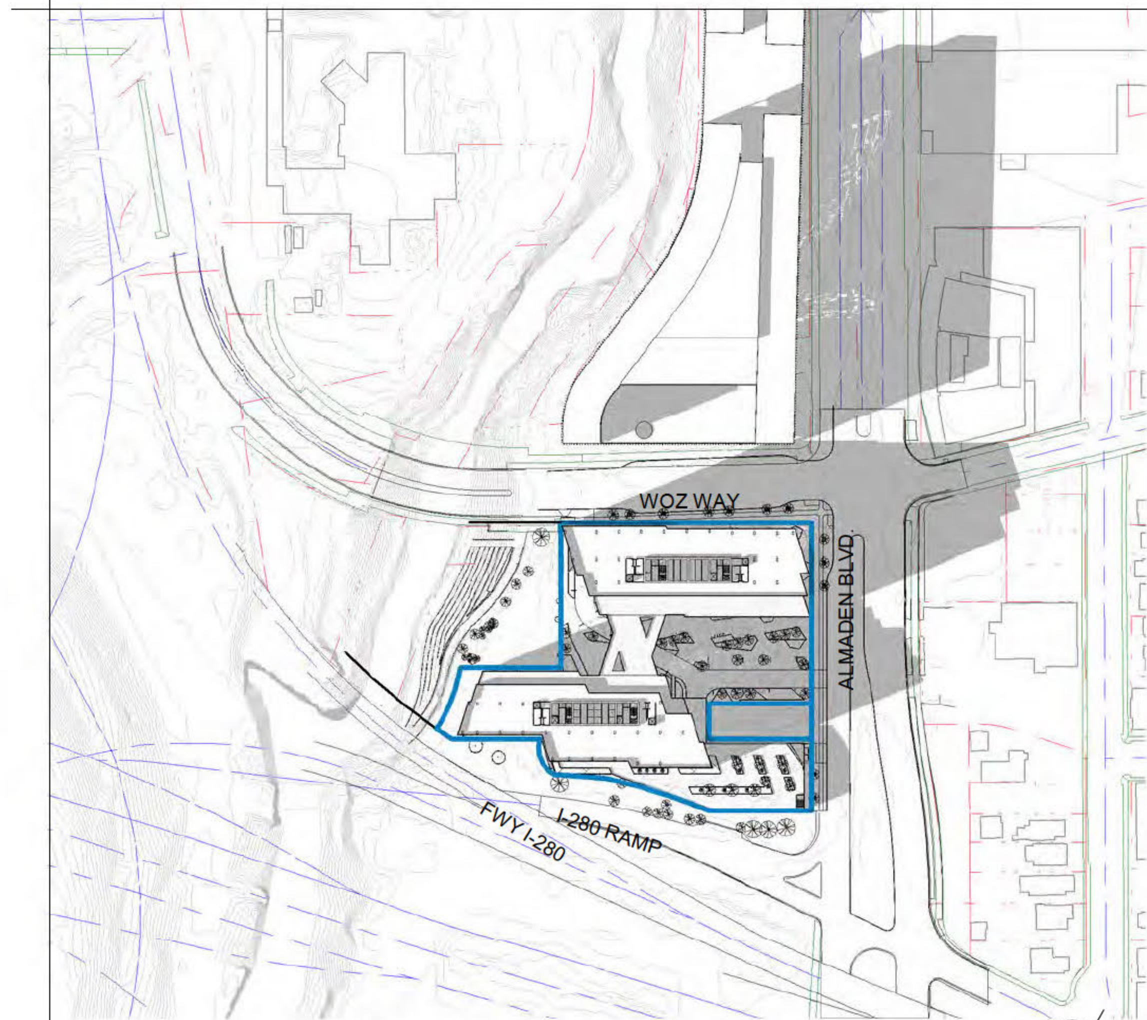
URBAN STREAM RESTORATION PRACTICES: AN INITIAL ASSESSMENT This assesses the performance of 24 urban stream restoration practices from sites around the Mid-Atlantic and Mid-west, and provides recommendations for improving their application in a variety of urban stream environments. It costs $20. Available through the Center for Watershed Protection. at http://www.cwp.org.

STREAM-BANK REPAIR GUIDANCE MANUAL FOR THE PRIVATE LANDOWNER - - GUADALUPE AND ALAMITOS CREEK – This focuses on erosion repair in mercury-contaminated streams, but it is relevant to a broad range of erosion repair projects. Some of the most relevant information from this document is contained in this Design Guide. This publication can be obtained from the Santa Clara Valley Water District.

MAINTAINING CORTE MADERA CREEK: A CITIZENS' GUIDE TO CREEK-SIDE PROPERTY PROTECTION – Created for the Town of Portola Valley and its residents to help guide bank stabilization and revegetation efforts along Corte Madera Creek, a tributary to San Francisquito Creek. The report was created to facilitate communications between the Town and private property owners who wish to address erosion and property loss. The document can be found at http://www.cityofpaloalto.org/public-works/jpa-projects.html.

GUIDELINES FOR BANK STABILIZATION PROJECTS: IN RIVERINE ENVIRONMENTS OF KING COUNTY – Produced by the King County Department of Public Works Surface Water Management Division, Seattle, Washington in 1993. This report is an exceptional manual that clearly and comprehensively describes the planning, design, permitting, and construction aspects of bank erosion repair. From a technical perspective , it is very applicable to California streams. This resource, including some of its illustrations, was used to help prepare this Bank Protection Design Guide.

EXHIBIT 4



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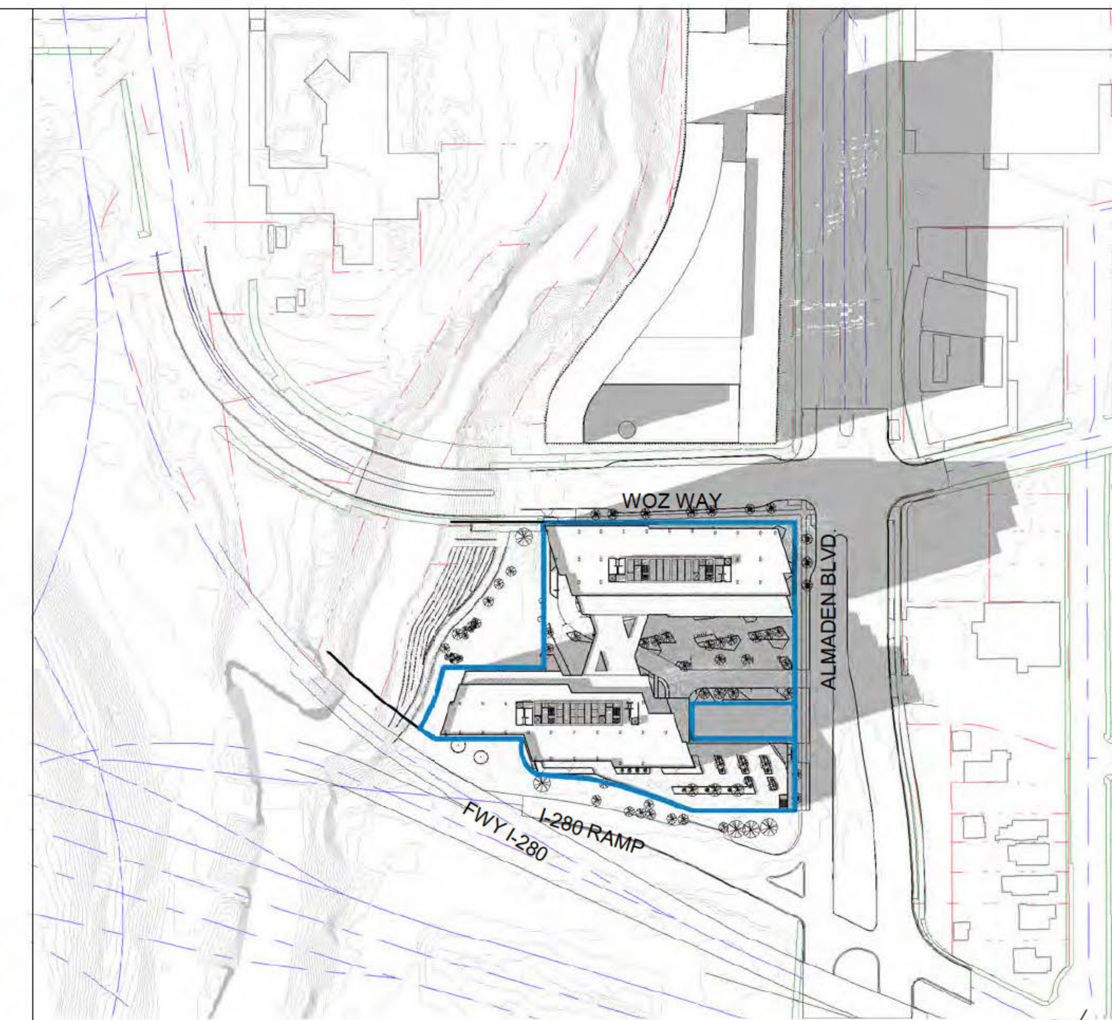
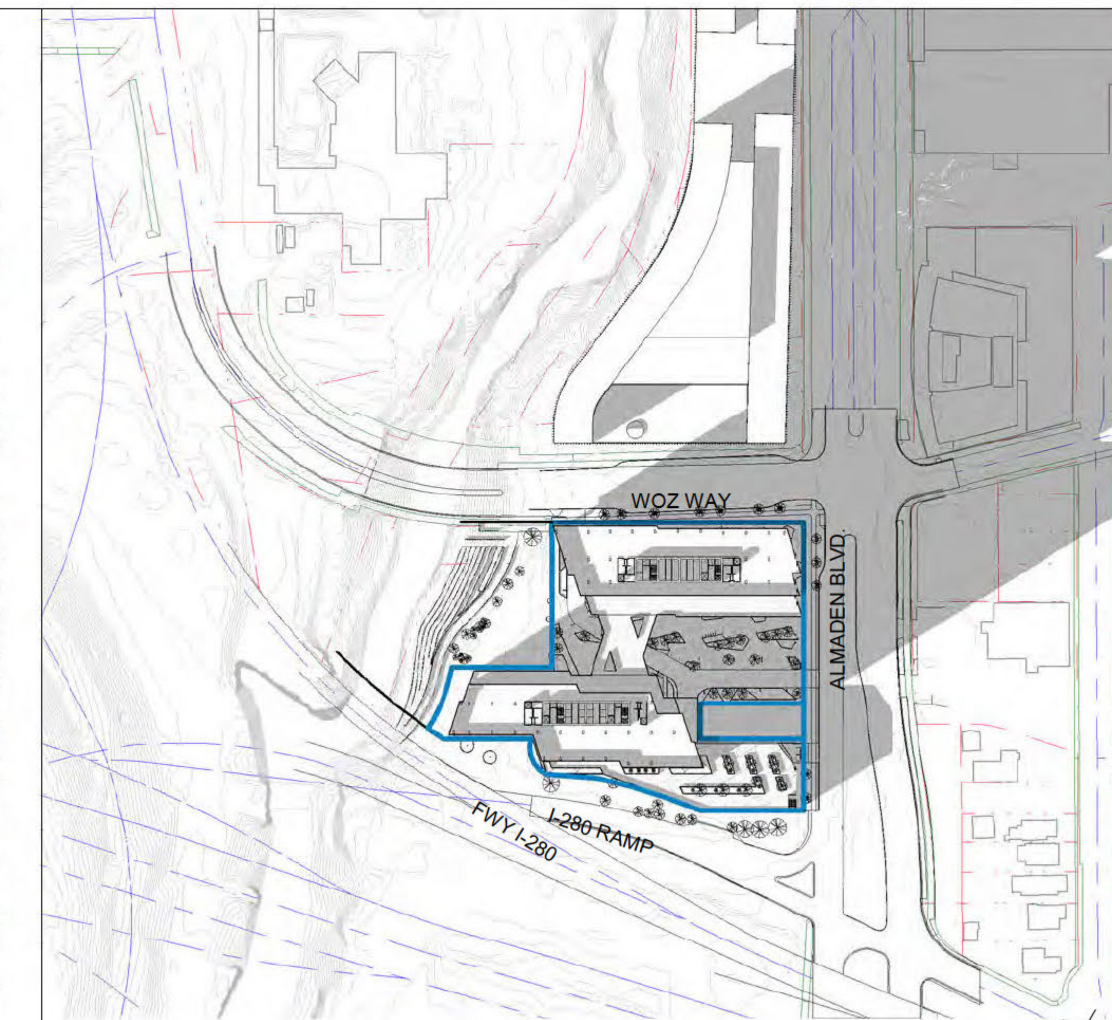
1" = 200'-0"

SS-SUMMER SOLSTICE (6/20) 3PM
1" = 200'-0"



SS-FALL EQUINOX (9/22) 3PM
1" = 200'-0"



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1" = 200'-0"

SS-SPRING EQUINOX (3/19) 12PM
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SS-SUMMER SOLSTICE (6/20) 12PM
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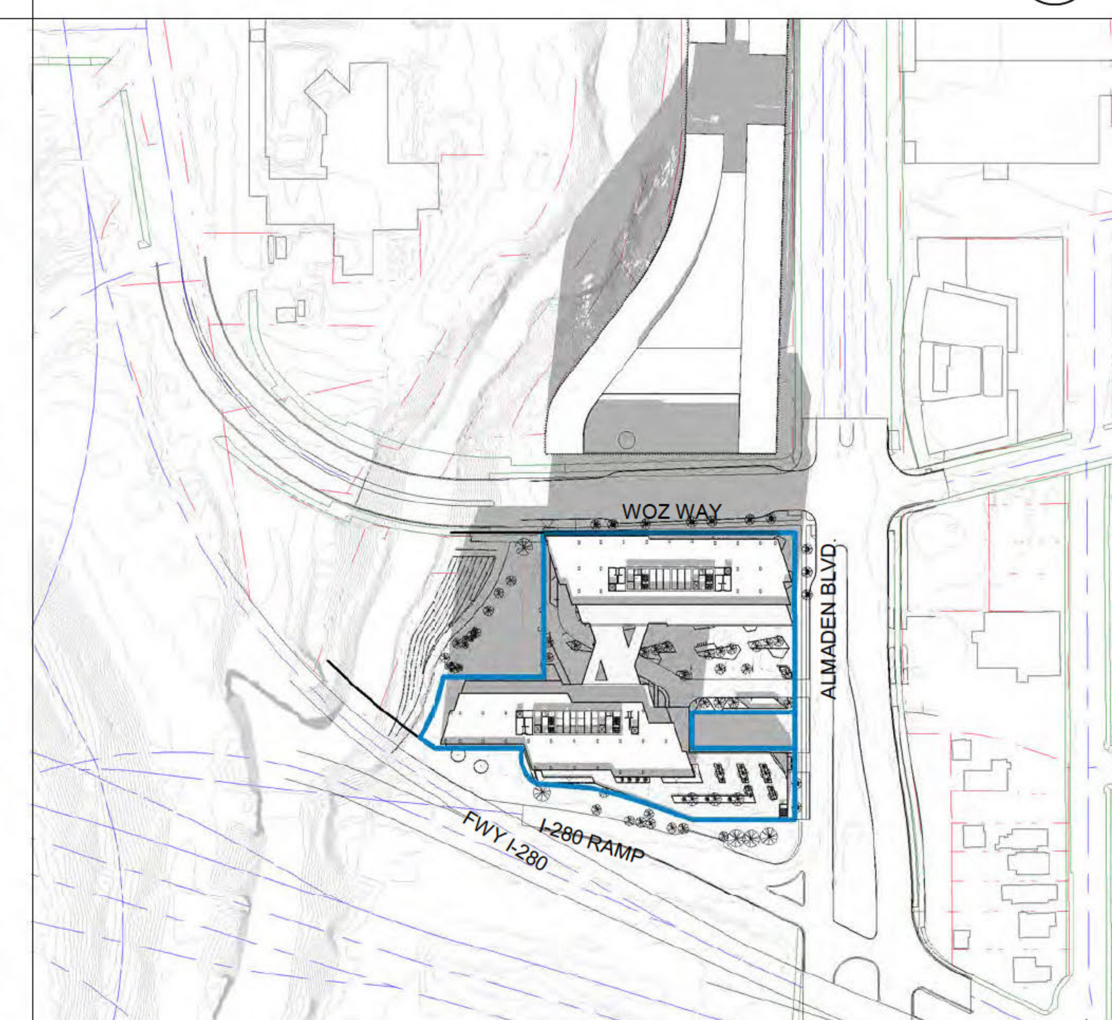

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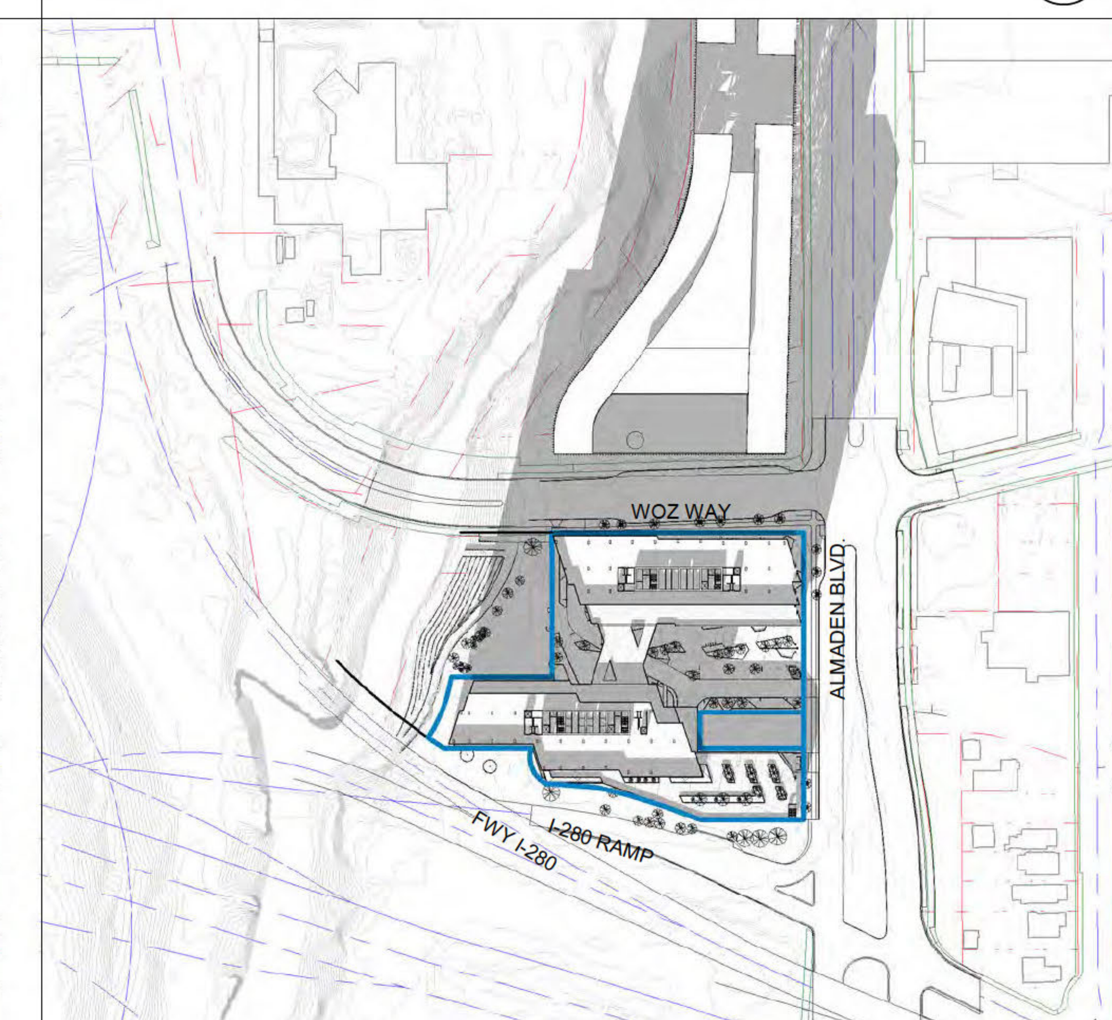

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1" = 200'-0"

SS-SPRING EQUINOX (3/19) 9AM
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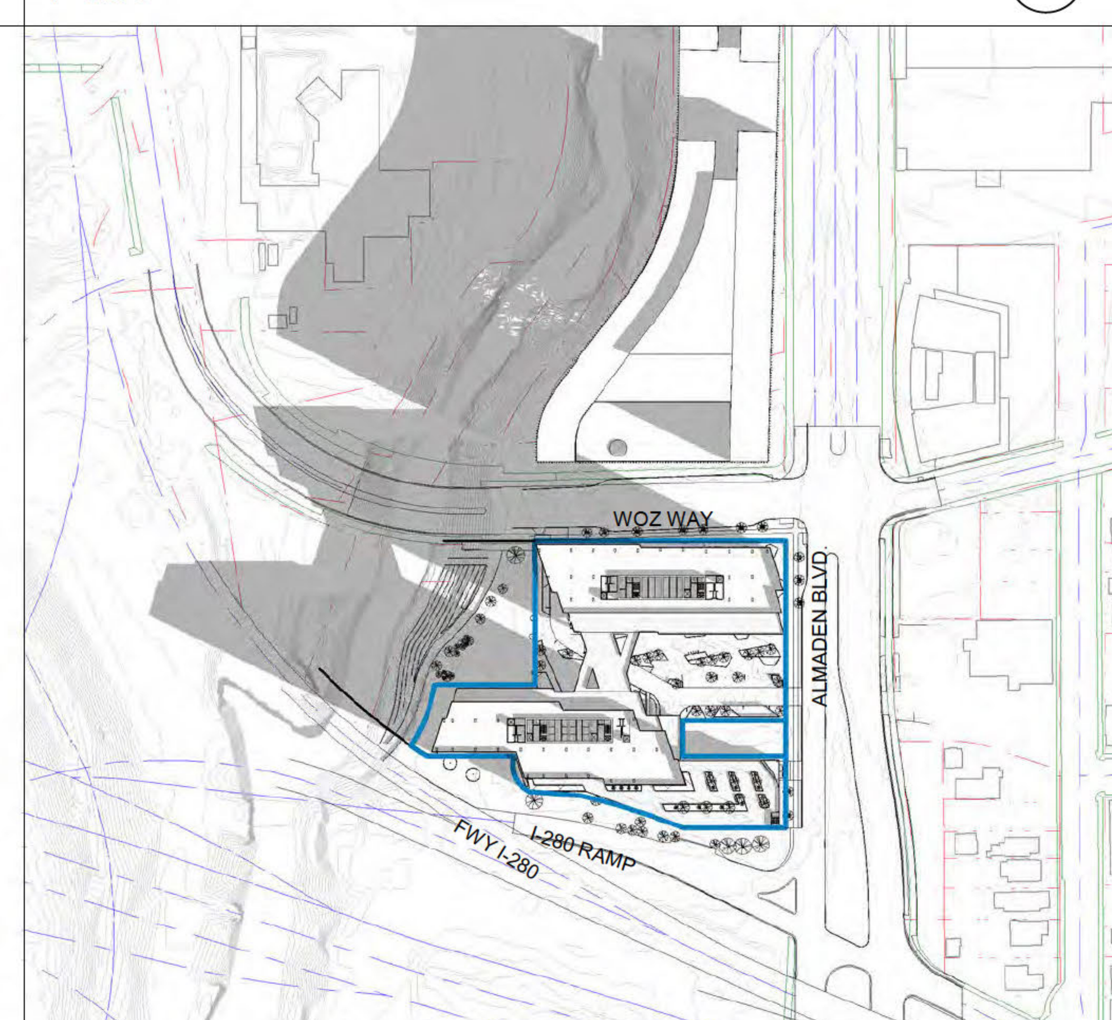

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1" = 200'-0"

SS-FALL EQUINOX (9/22) 9AM
1" = 200'-0"

SS-WINTER SOLSTICE (12/21) 9AM
1" = 200'-0"

SDP SET GP19-008/H20-004

C2K
ARCHITECTURE
1645 NW HOYT
PORTLAND OREGON 97209
503 444 2200

CITY STAMP

WOZ WAY

OWNER:
KT URBAN

ADDRESS:
280 Woz Way
San Jose, CA

PROJECT NO.: 18120
DRAWN: NM
DATE: 09 APR 2020
SDP SET GP19-008/H20-004

REVISION: DESCRIPTION:
03 AUG 2020 RESPONSE TO COMMENTS #1

PROGRESS SET

SHEET TITLE:
SUN SHADOW STUDY

SCALE:
SHEET NO.:
G150

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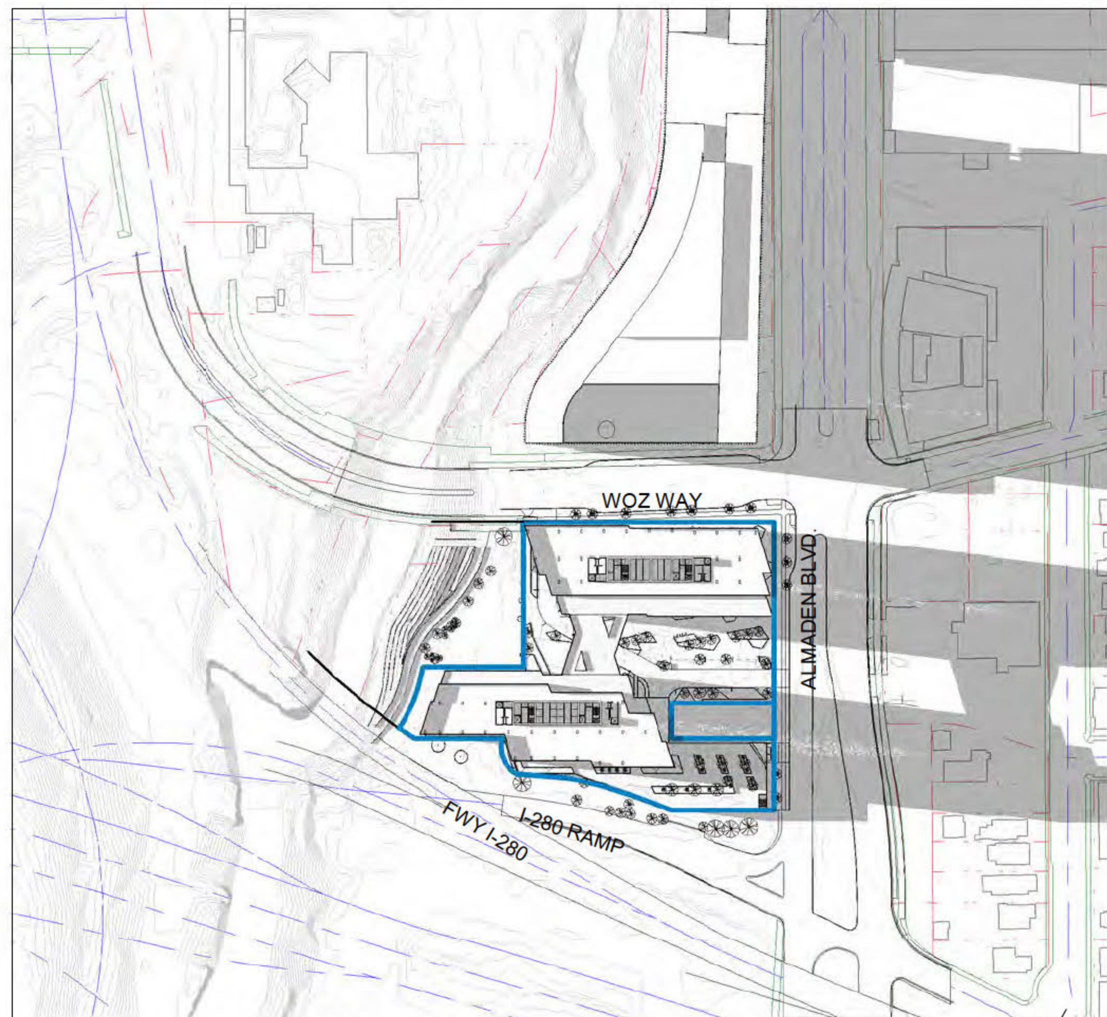

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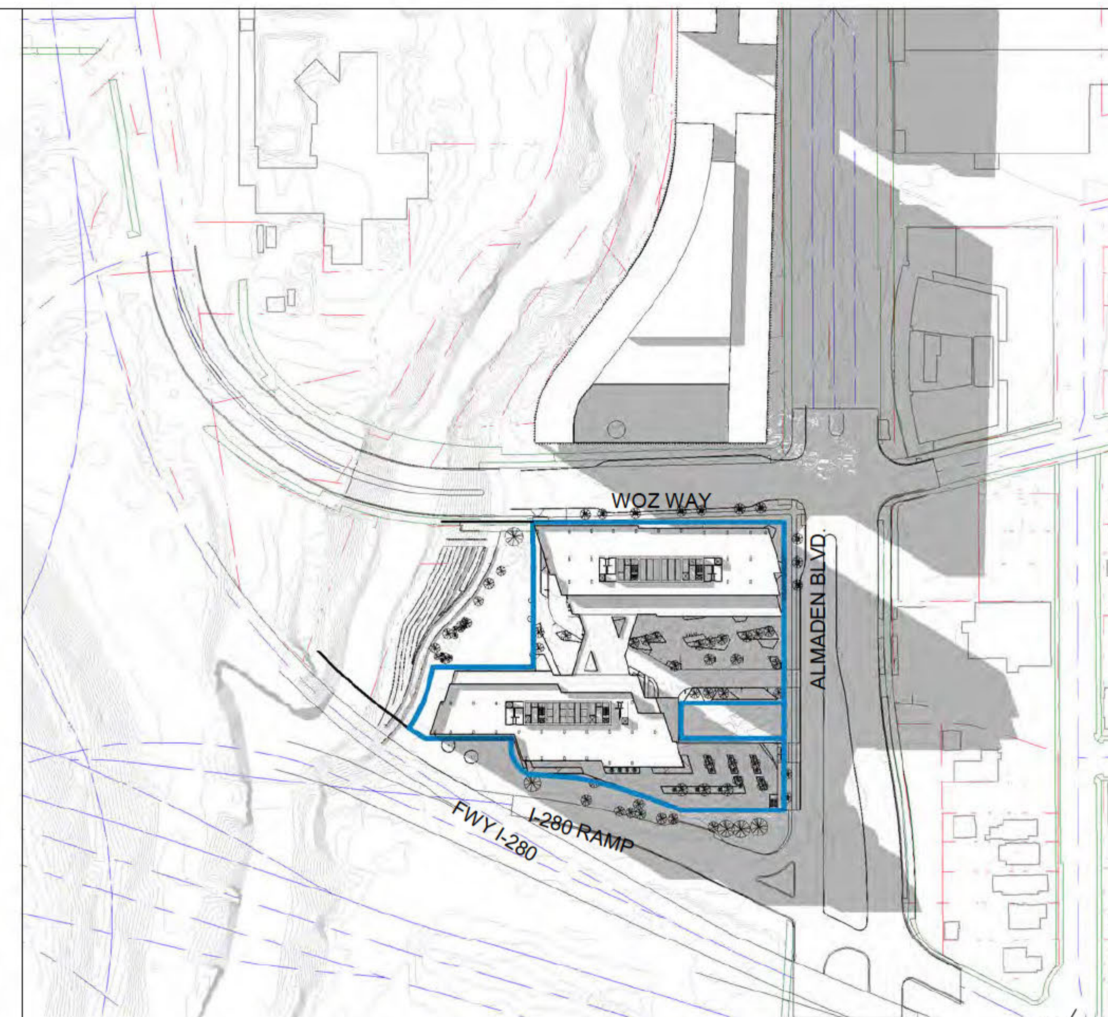

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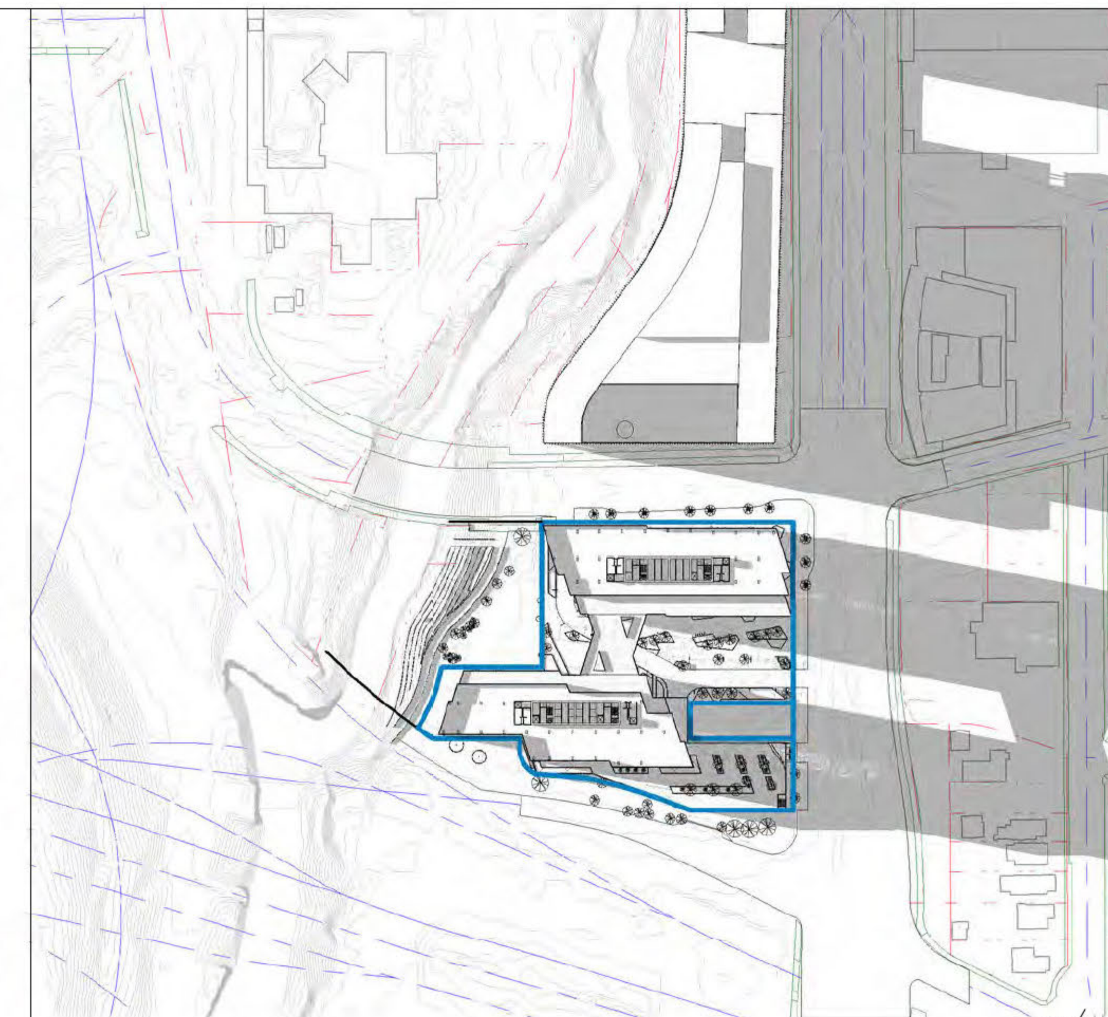
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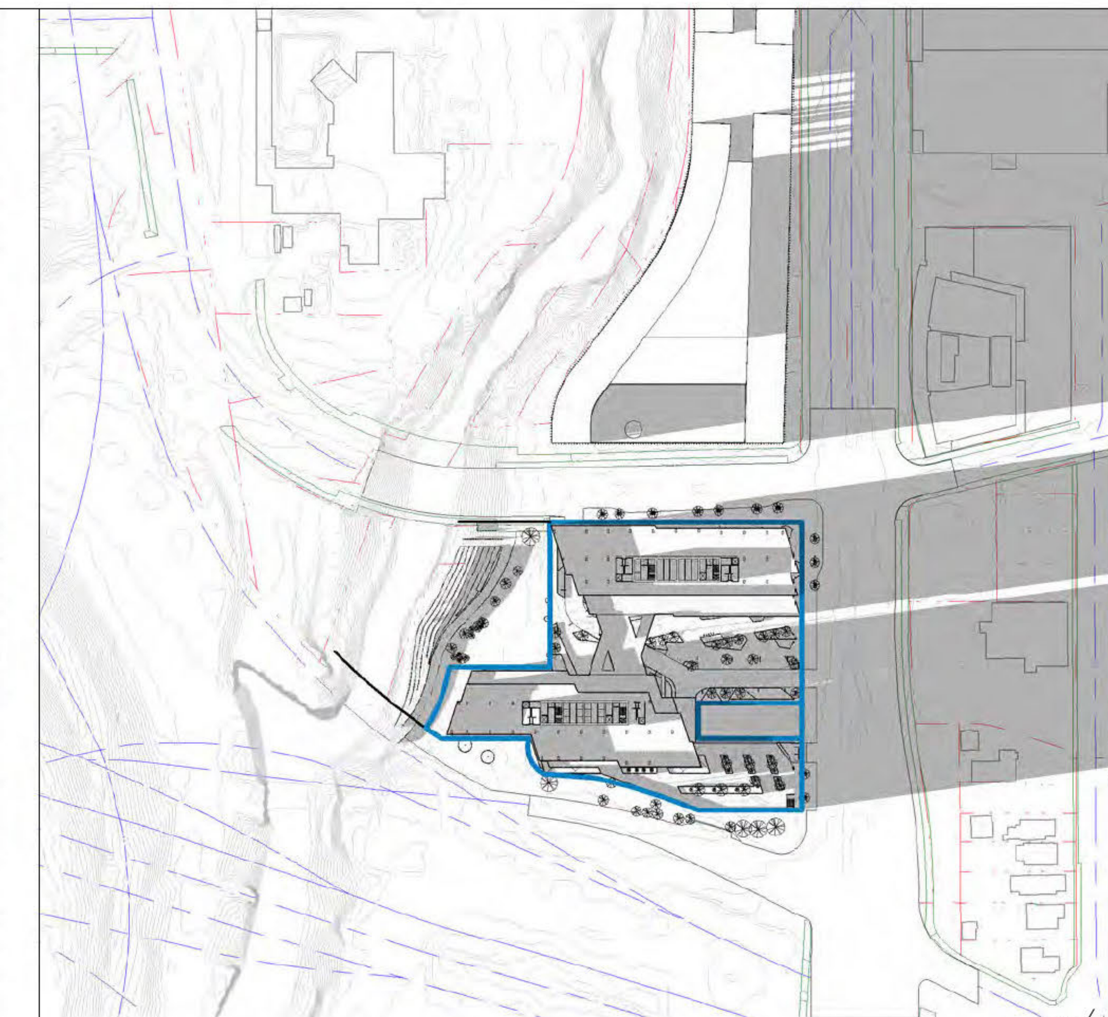
1" = 200'-0"


SS-WINTER SOLSTICE (12/21) 5PM
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SCALE:
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G151