Re-Oaking North Bay

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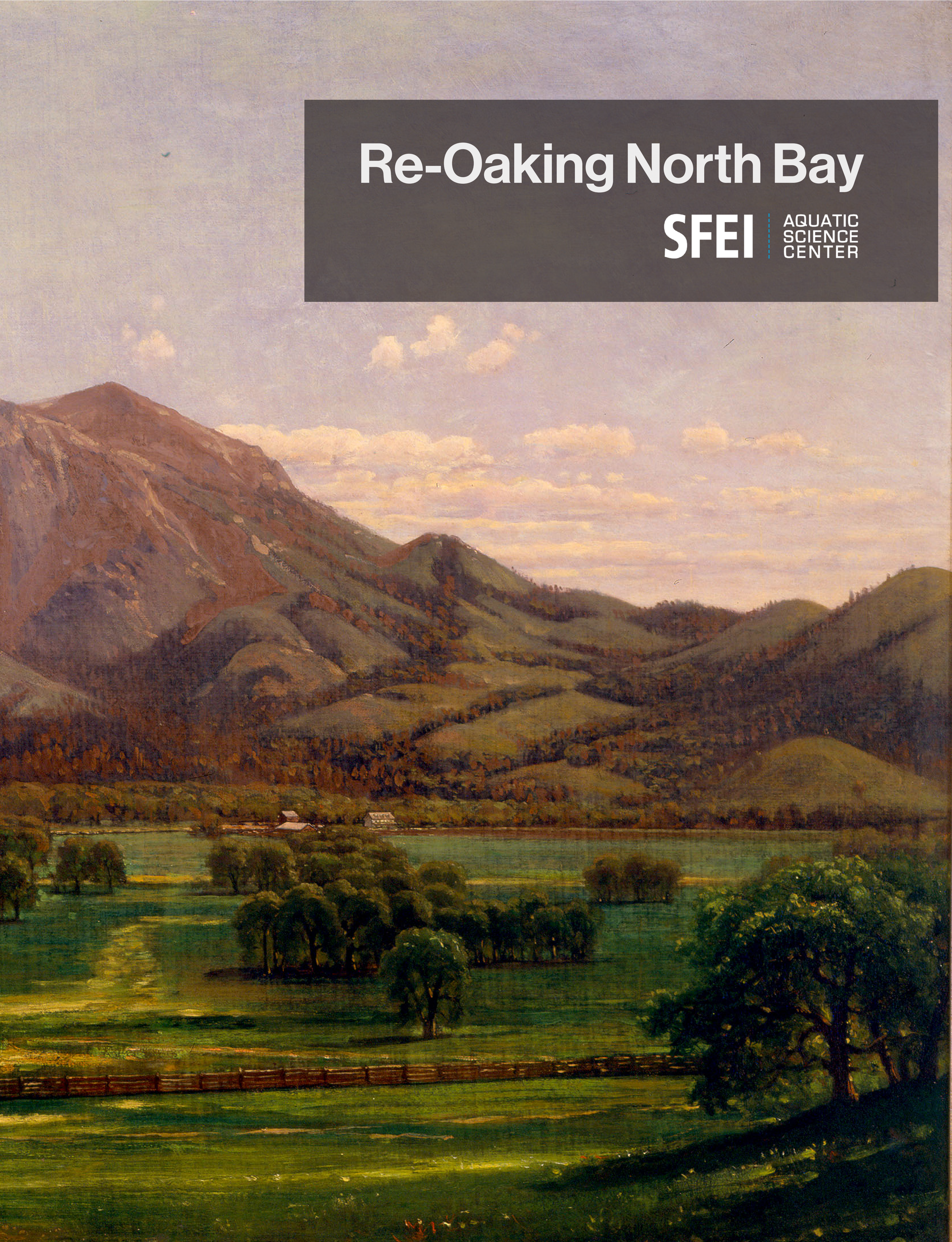

Re-Oaking North Bay:

A strategy for restoring native oak ecosystems, focusing on Napa and Sonoma valleys

Prepared by SFEI

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For more information, visit www.sfei.org/projects/re-oaking

Cover artwork: Virgil Williams, Mount St. Helena from Knight's Valley, 19th Century (courtesy of the Oakland Museum of California, The Kahn Collection, A65.63). Photo (above) courtesy of Shira Bezalel (SFEI).

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Introduction

Oaks are iconic trees in California, the defining feature of savannas and woodlands in many parts of the state. For millennia, these majestic trees have provided the ecological foundation upon which thousands of other organisms depend. Their cultural significance is equally profound: they are of central importance to diverse indigenous groups, and are prized for the many benefits they provide California residents.

Vast expanses of oak savanna historically occupied the rich alluvial soils of Napa and Sonoma valleys. The immense and long-lived valley oak (*Quercus lobata*) dominated these savannas, accounting for more than 65% of trees (Dawson 2008, Grossinger et al. 2012). Early observers described the valleys as "studded with groups of oaks" (Marryat 1850), and extolled the "magnificent oaks" that were "the glory of the landscape scenery" (Smith and Elliott 1878). Black oak (*Q. kelloggii*), coast live oak (*Q. agrifolia*), and other oak species were present in smaller numbers on the valley floors and were more abundant in the hillsides (Dawson 2008, Grossinger et al. 2012).

> *"The fields have scattered over them many most grand oaks, which would be an ornament to any park with their broad spreading branches, drooping at the ends like those of an elm—majestic trees."*
>
> **— William Brewer**
> describing Napa Valley in 1861

Over the past two centuries, however, much of this oak savanna has been cleared to make way for orchards, vineyards, and towns. In Napa Valley, the number of mature trees has declined from an estimated 45,000 in the early 1800s to less than 1,000 today (Grossinger et al. 2012). Valley oak habitat has been particularly affected by clearing and fragmentation: in many areas of the state, loss of valley oak woodland exceeds 90% (Kelly et al. 2005, Whipple et al. 2011).

Documentation of this loss, and recognition of the value of oaks for both people and nature, has led to a growing desire to restore this unique ecosystem and bring back many of the benefits that oaks provide. Despite the significant changes the North Bay landscape has experienced since European settlement, there are opportunities to restore oaks in settings as diverse as backyards, parks, streets, farms, vineyards, and creeksides.

Re-oaking North Bay is an initiative to restore our native oak communities in places where they could once again thrive and benefit our landscapes into the future. Land managers, public agencies, private landowners, and others interested in re-oaking the North Bay are seeking guidance on where to prioritize restoration efforts in order to maximize ecological benefits. This document provides a framework for re-oaking the Napa and Sonoma valley floors as a first phase of re-oaking efforts in the North Bay. It complements oak woodland management efforts in the broader North Bay region. The goal of Re-oak North Bay is to provide a spatial strategy for re-oaking that:

- *Re-establishes a healthy valley oak population along with other associated oak species such as black, blue, Oregon, and coast live oak*
- *Provides high quality habitat for wildlife*
- *Facilitates wildlife movement and provides genetic connectivity between oaks within and across valleys*
- *Is sustainable under climate change and compatible with fire-ready guidelines*
- *Provides valuable ecosystem services (e.g., cooling, carbon storage, runoff attenuation)*

Given the historic prevalence and loss of valley oaks in these areas, the project centers around this species. It draws on previous re-oaking guidance developed for Silicon Valley (Spotswood et al. 2017) and historical ecology research on Napa and Sonoma valleys (Dawson 2008, Grossinger et al. 2012). The study area used in this document includes the alluvial portions of the valleys and excludes historical baylands.

Acorn Woodpecker (Photo courtesy of Becky Matsubara, CC by 2.0)

Western Fence Lizard (Photo courtesy of Allan Hack, CC by 2.0)

The Many Benefits of Oaks

Oak woodlands and savannas historically served a variety of ecological and cultural roles in Napa and Sonoma valleys. While only a small fraction of the region's historical oak habitats remain today, they continue to support wildlife and provide various benefits to people.

Oak woodlands harbor some of the highest plant and animal diversity in California, a region that is in itself a biodiversity hotspot (Myers et al. 2000, Tietje et al. 2005). More than 300 vertebrates, 2,000 plant species, and 4,000 insect species inhabit oak woodlands during all or part of their lives (Tietje et al. 2005). Dozens of bird species rely on acorns for food, and in turn help to disperse acorns across the landscape (Zack et al. 2002). Dense oak canopies also provide shelter for nesting birds, while leaf litter and fallen branches provide shelter for various terrestrial animals. Oaks' shade helps maintain soil moisture, while fallen leaves add nutrients to the soil — conditions that together support understory plant diversity (Dahlgren et al. 2003, Grossinger et al. 2012). Oaks grow in a range of densities, creating habitat for diverse plants adapted to various amounts of light and heat (Meadows 2007).

In addition to supporting native biodiversity, oaks provide various ecosystem services for people living in the region. Oaks remove more carbon dioxide from the atmosphere per year than many other common landscaping trees (Spotswood et al. 2017). Planting oaks thus helps to mitigate the effects of climate change. Oaks also temper the climate on a more local scale, providing shade that can lead to temperatures 9°F lower than in the surrounding environment (Parker & Muller 1982). Valley, black, blue, and other native oak species evolved to tolerate California's seasonal cycles of drought and are able to provide these services while requiring little water (Mahall et al. 2009).

Oak trees likewise hold cultural value in the North Bay. Acorns historically served as an important food source for various tribes in California, including the Wappo (Onasatis), Coast Miwok, Wintun, and Patwin peoples indigenous to Napa and Sonoma valleys. Native Californians developed practices to increase acorn yields through pruning and to foster the growth of large oaks in open woodlands through controlled fires. Despite the upheaval and cultural disruption caused by colonization in Napa and Sonoma valleys, many native people continue the tradition of harvesting acorns today (Ortiz 2008). True restoration of oak ecosystems in the region will involve active oak stewardship and care — practices developed in conversation with local Native American tribes and drawing on their expertise.

Brush Rabbit (Photo courtesy of Allan Hack, CC by 2.0)

California Sister (Photo courtesy of Franco Folini, CC by 2.0)

CLIMATE CHANGE

As climate change leads to higher average temperatures across California, the area where valley oaks grow is predicted to shift northwards and to higher elevations (Crookston 2010, McLaughlin and Zavaleta 2012). Recent research suggests that valley oaks are better adapted to cooler temperatures than they are currently experiencing, making them particularly vulnerable to the effects of climate change (Browne et al. 2019). In Napa and Sonoma valleys, where both temperature and drought stress are predicted to increase (Flint and Flint 2014; Micheli et al. 2016a, 2016b), the future viability of valley oak may decrease somewhat (Crookston 2010), though the predicted response varies widely across different climate change projections (Ackerly 2014). In the southern Mayacamas mountains (between Napa and Sonoma valleys), valley oak, coast live oak, and blue oak are thought to be relatively stable under future climate conditions (Climate Ready North Bay 2015). At the local scale, creeks and areas of high groundwater may serve as increasingly important refuges for valley oaks in the future, and particularly for less drought-tolerant saplings (McLaughlin and Zavaleta 2012).

Given that oak populations are shifting northward and drought stress is increasingly threatening sapling survival, action to restore oak ecosystems is especially important today. Saplings that are established now may be more likely to survive as mature trees than saplings established decades from now. Because valley oaks are long-lived, young trees that reach maturity will help ensure the persistence of oak ecosystems in the North Bay for hundreds of years. Planting should emphasize locally sourced acorns adapted to local conditions (Montalvo et al. 1997), though consideration may also be given to incorporating acorns from climates resembling projected future conditions for Napa and Sonoma valleys (Browne et al. 2019).

Re-Oaking Spatial Strategy Methods

Priority areas for re-oaking Napa and Sonoma valley floors were identified by comparing present and past distributions of valley oaks, analyzing opportunities in the modern landscape, and demarcating areas to exclude based on valley oaks' physiological constraints.

Past/Present Comparison

Areas of recent oak loss (since 1942) were identified using the locations of contemporary and historical oaks. Contemporary large (>132 inches in circumference) oak trees were mapped in 2002 in Napa Valley by Jake Ruygt and 2005 in Sonoma Valley by Arthur Dawson. The historical distribution of oak trees was identified from existing large oaks (projected to have been present in 1942 based on age-size relationships), oaks present in 1942 aerial images of Napa and Sonoma valleys, and (for Napa Valley) 1853-1867 General Land Office survey oak observations (Ruygt 2002; Dawson 2008; SFEI 2012a, 2012b). Buffer circles with 500-foot radii were drawn around historical and modern oak points to represent areas where cross-pollination between oaks was likely possible (Spotswood et al. 2017), and modern buffers were then erased from historical buffers to isolate areas of loss (orange areas). Historical perennial wetlands were likewise erased from historical buffers since these habitats were likely unsuitable for oaks (Dawson 2008, Grossinger et al. 2012). Areas of recent oak loss also include portions of oak woodland that sustained canopy damage (≥60%) in the 2017 Nuns, Tubbs, and Pocket Fires (NASA et al. 2017). The Atlas Fire was not included because it is mostly outside of the study area.

Areas of oak loss prior to 1942 (yellow areas) were estimated by subtracting existing oak habitat (Thorne et al. 2016, Sonoma Veg Map 2017) from the historical extent of oak savanna and riparian woodland in Napa Valley (Grossinger et al. 2012) or areas of high soil suitability for oaks for Sonoma Valley (assumed to represent likely historical oak extent; Dawson 2008).

Analysis of Contemporary Landscape

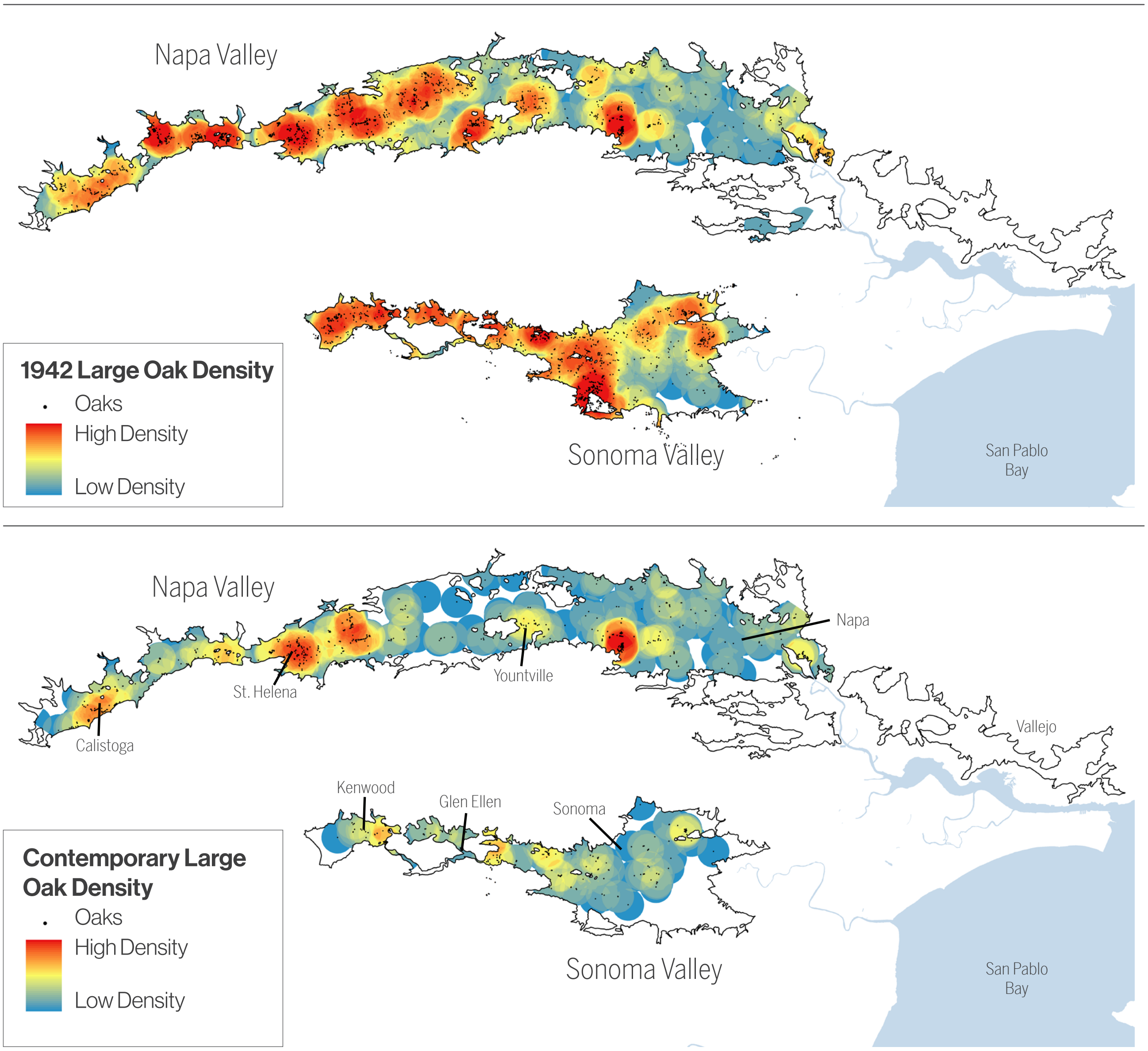
In addition to historical changes in oak distribution, patterns in the contemporary landscape were analyzed to locate areas that may maximize re-oaking benefits. To identify potential opportunities for creating oak nodes, buffer circles with 500-foot radii (green areas) were drawn around existing large oaks (Ruygt 2002, Dawson 2008). To identify potential oak corridors along creeks, streams (SFEI 2016) were buffered by 100 feet.

Assessment of Constraints

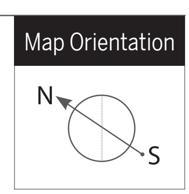
Areas with soil types, groundwater levels, or other physical conditions that limit oak growth may be unsuitable for oak restoration (hatched areas). Valley oaks require well drained soils and are unlikely to tolerate clay-rich soils. Soils with clay texture were identified using data from the NRCS Soil Survey Geographic Database. Additional areas with low soil suitability in Sonoma Valley were identified based on mapping conducted by Dawson (2008). In addition, valley oak root systems are not adapted to withstand very shallow water tables (Cooper 1926), while water tables deeper than 60-80 feet may be inaccessible to oak taproots (Lewis and Burgy 1964, Brown and Davis 1991). Areas likely outside the valley oak's groundwater depth tolerance (<5 ft in Spring or >80 ft in Autumn) were identified using depth to groundwater maps for Napa and Sonoma (LSCE 2015, 2018; SCWA 2016a, 2016b); these sites may be unsuitable for oak restoration in the absence of irrigation or other active management. Modern wetlands, identified from vegetation mapping for Napa and Sonoma counties, were also assumed to have groundwater levels unsuitable for oaks (Thorne et al. 2016, Sonoma Veg Map 2017).

Limitations

The opportunities and constraints map is intended to serve as a starting point for identifying landscape-scale re-oaking priority areas, but regional data may not accurately capture conditions on individual properties. For example, areas filled in with imported soil during development (e.g., CAA 2018) may now be more amenable to oaks. In addition, existing immature trees can indicate suitable areas for oak restoration, but location data for younger trees is not currently available. Practitioners should therefore assess the conditions on individual properties before planting oaks. Additional factors beyond the scope of this document should be considered when re-oaking, such as planting season and the need for active management, irrigation, or monitoring. Experts from various local organizations such as the Napa and Sonoma Resource Conservation Districts can provide further guidance to support those interested in re-oaking.

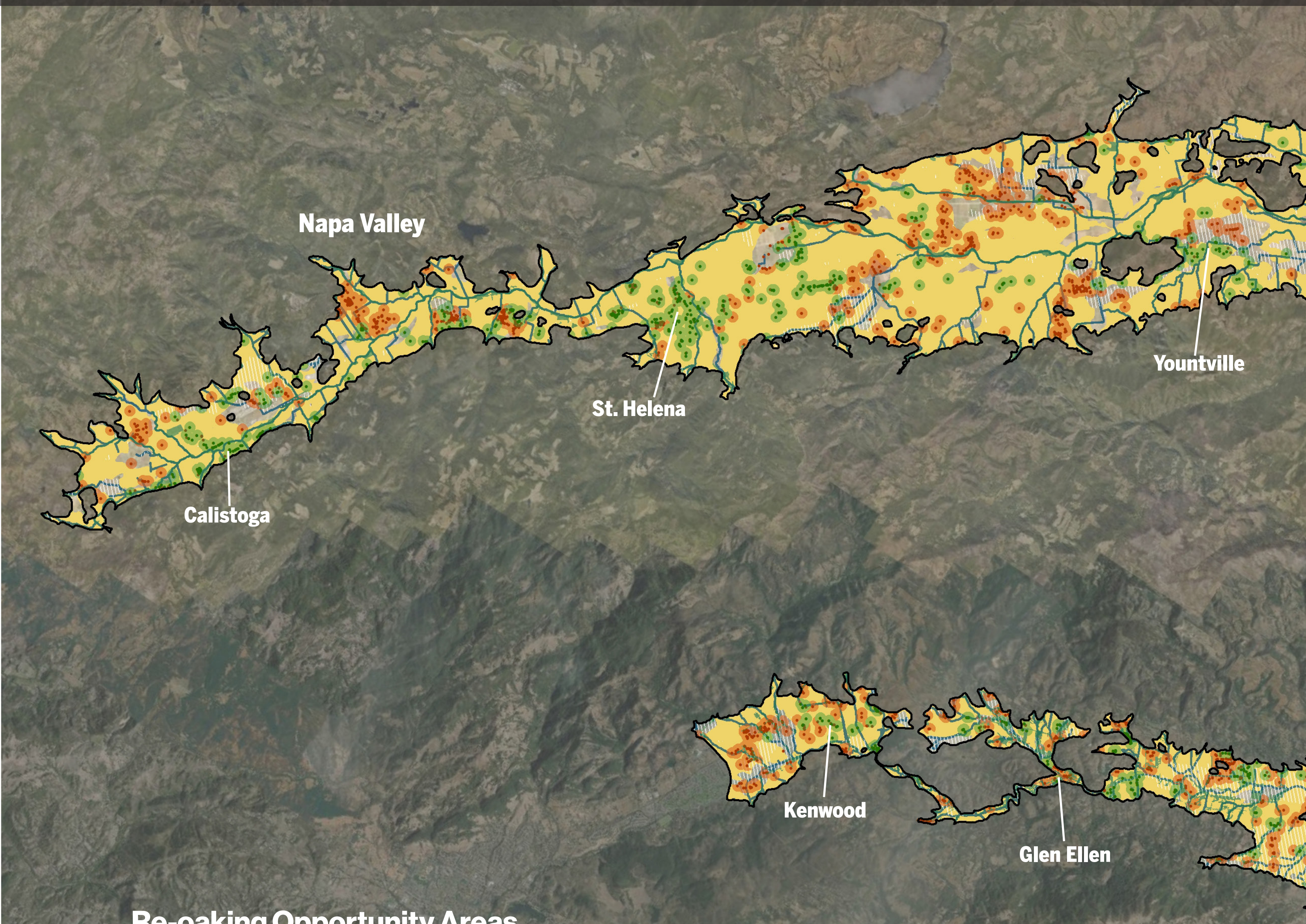


Densities of historical (above) and contemporary (below) oak trees in Napa and Sonoma valleys. In both maps above, high density areas included more than 85 large oaks (>132 inches in circumference or >42 inches in diameter at breast height) in a 1-km radius, whereas low density areas had 1 large oak within 1km. These maps likely underestimate large oak density and may not represent overall oak density.



Re-Oaking Spatial Strategy

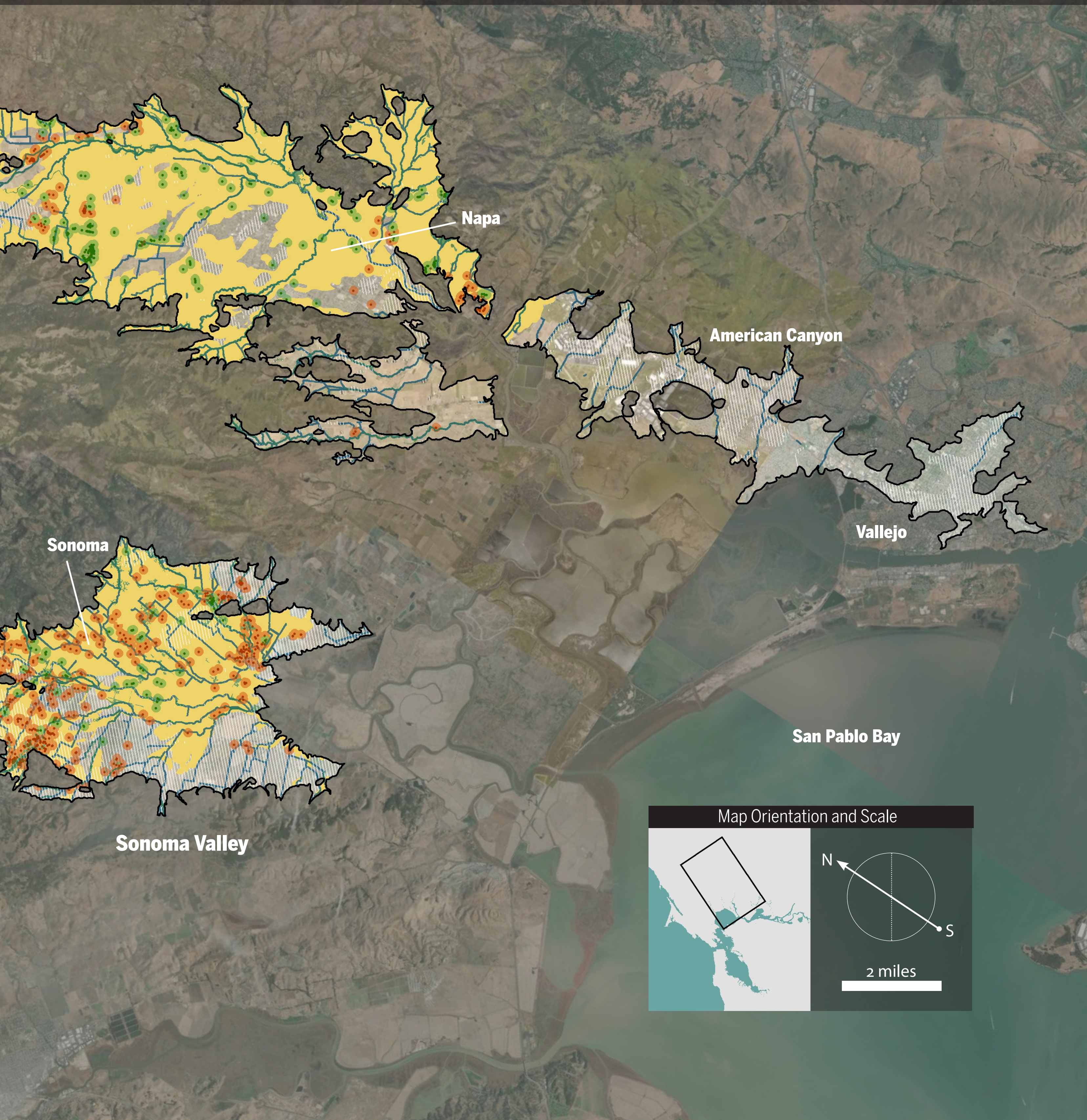
This spatial strategy map illustrates some of the major re-oaking opportunities on the Napa and Sonoma valley floors. Areas of recent (orange) or historical (yellow) valley oak loss indicate areas of the valleys that once supported valley oak habitats and could be appropriate sites for oak restoration. In addition to areas of loss, existing groups of large oaks (green) are often strategic areas in which to focus restoration efforts: creating or expanding oak nodes in these areas by



Re-oaking Opportunity Areas

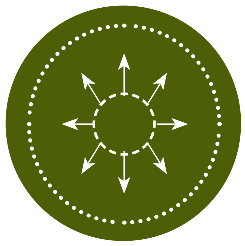
- Lost Historical Oak Habitats (circa 1850)
- Areas of Significant Recent Large Oak Loss (1942-2005)
- Areas with Existing Large Oaks
- Riparian Corridors for Potential Oak Planting
- Potential Soil or Groundwater Constraints
- Lost Historical Oak Habitats with Potential Soil or Groundwater Constraints

planting trees and associated understory plants will provide a range of biodiversity benefits. Similarly, creating or widening corridors of oaks along tributaries (blue) or other linear features can facilitate wildlife movement within and across the valleys. In some parts of the valleys, incompatible soil types, groundwater levels, or other constraints may make re-oaking impractical (hatched areas), so individual site evaluations should be conducted before planting oaks.



Re-Oaking Strategies

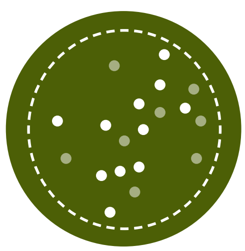
The re-oaking spatial strategy map highlights various priority areas for restoring valley oaks on the Napa and Sonoma valley floors, including around existing oak nodes, along riparian corridors, and in areas of recent and historical oak loss. The discussion below outlines the ecological bases of these complementary approaches and how to apply them in different land use settings. Successfully implementing these approaches will require careful attention towards oak sourcing (e.g., through planting locally sourced acorns) and ongoing stewardship from interested community members.



1. Expand existing nodes

Groups, or nodes, of multiple oak trees in relatively close proximity provide habitat for animals to forage, reproduce, and take shelter. Nodes are generally more beneficial to wildlife than widely spaced trees. For example, oak nodes 15-20 acres in size and with at least 20 trees are likely necessary to support acorn woodpecker colonies (Spotswood et al. 2017). Nodes also allow trees to cross-pollinate and thus help preserve genetic diversity (Pluess et al. 2009).

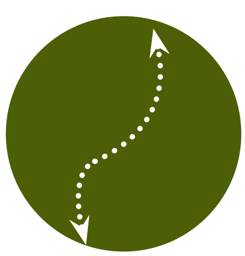
Large oaks (or groups of large oaks) are particularly important for wildlife, and are rare relative to their historical abundance in Napa and Sonoma valleys. Thus, where possible, oak nodes should be established around existing large trees or clusters of large trees.



2. Increase density within nodes

In addition to expanding oak nodes, efforts to increase tree density within existing nodes will also benefit local biodiversity. Historically, most of the oak habitat in Napa and Sonoma valleys was oak savanna, consisting of relatively widely spaced trees scattered across grasslands and wildflower fields (Dawson 2008, Grossinger et al. 2012). Oak density within the savanna varied substantially, with groves of denser trees in some areas and sparser tree cover in others.

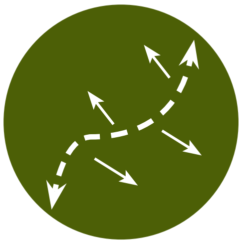
Within oak nodes, individual oak trees should be spaced close enough together to facilitate wildlife movement and ensure that trees can cross-pollinate. Historically, large oaks were often clustered within 200 feet of each other (A. Dawson pers. comm.). In order for successful pollination to occur, oaks within nodes should be spaced no more than 500 feet apart (Sork et al. 2002, F. Davis pers. comm.).



3. Create corridors

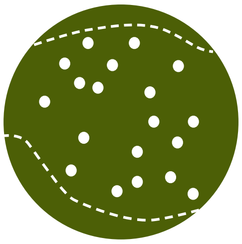
Continuous corridors of oak trees facilitate connectivity between oak populations, and provide opportunities for wildlife to move both across the valleys (i.e., between oak nodes) and into adjacent upland habitats. Such connections are critical for supporting biodiversity in developed areas and maintaining plant, bird, and other wildlife populations that are resilient to disturbances like fires and floods, and to future climate changes (Tewksbury et al. 2002, Beninde et al. 2015). Tributaries of the

Napa River and Sonoma Creek are particularly high priority areas for creating oak corridors, as these waterways provide natural pathways between upland oak populations on either side of the valley (Gray et al. 2018). These "oak corridors" may encompass, but are not synonymous with, the corridors of riparian vegetation that directly surround the creek channel itself. In addition to tributaries, other linear features like highway, city streets, farm roads, margins of agricultural fields, or property boundaries can provide good opportunities for creation of oak corridors. Oak trees can be densely planted to ensure continuous canopy cover along mobility corridors, improving connectivity and reducing stormwater runoff.



4. Widen existing corridors

Various wildlife species can use oak corridors to travel across the landscape, but overly narrow corridors will exclude many of these species (Holmes et al. 1999, Hilty and Merenlender 2004, Collins et al. 2006). Though portions of many creeks within the valleys currently support riparian forests that contain oaks, these corridors are often too narrow to support the full suite of oak-associated wildlife. Likewise, existing corridors along roads and other linear features often consist of a single line of trees. Widening existing corridors through re-oaking in surrounding areas can greatly increase the ecological value of these oak corridors.



5. Restore areas of oak loss

Areas of recent or historical oak loss can also be prime locations for oak restoration. Though many aspects of the landscape have been altered in Napa and Sonoma valleys, the historical presence of oaks is often a strong indicator that the physical conditions of a particular area may still be suitable for oaks, at least at a coarse scale (site-specific assessment is needed to evaluate suitability at the site scale).

Because large areas of Napa and Sonoma valleys historically supported oak savanna or woodland, much of which has been lost, an evaluation of oak loss produces an extensive map of potential restoration opportunity areas. While re-oaking is likely appropriate and desirable across much of this zone, some areas present particularly promising re-oaking opportunities. Alluvial fans, for example, historically supported high densities of valley oaks (Griffin & Critchfield 1972). Areas of oak loss that overlap with potential oak nodes and corridors meanwhile offer opportunities to maximize the benefits of oaks.

6. Protect vulnerable populations

While many of the re-oaking concepts presented here entail planting or other active restoration efforts, monitoring, protecting, and preserving existing oak trees (and especially large trees) is equally important, particularly because newly planted trees will take decades to reach maturity. Outreach and technical support for land managers, public outreach to address common concerns, and tree protection ordinances can help ensure that these valuable trees are protected.


1
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Re-oaking Across the Landscape

The general re-oaking concepts discussed above can be broadly applied. Opportunities for restoring native oak populations will vary by land use type . Re-oaking in these various contexts will help to bring the diverse benefits of oaks to people and wildlife across the region.

1. Agricultural Areas

Oaks can be reintroduced to agricultural settings by planting along roads, in fields and around wineries and other structures. These iconic trees can add to the character of event venues and shade agricultural fields, offering refuge to farm workers, visitors, and animals in the hot summer months.

2. Tributary Corridors

Tributaries present a unique opportunity for creating and widening oak corridors that link hillside and valley oak populations. These landscape-scale connections are ever more important given the extent of habitat fragmentation.

3. Urban Areas

Many towns and cities were established in areas with extensive oak groves. Over time, expanding development led to substantial losses of oaks on the valley floor. Re-oaking in urban areas can bring the benefits of oaks closer to people. Streets, yards, schools, golf courses, parking lots and parks are only some of the many places that can be enhanced with oak plantings.

Legend

Existing native oaks

Proposed native oaks

Other existing tree species

FIRE

Historically, oak woodlands in many parts of the state experienced frequent, low-intensity ground fires (Van de Water and Safford 2011). In many areas, including Napa and Sonoma valleys, indigenous tribes used burning to maintain an open understory within oak woodlands and to aid foraging and hunting (Greenlee and Langenheim 1990, Anderson 2006, Grossinger et al. 2012). Oaks have evolved a number of adaptations to tolerate frequent low- to moderate-intensity fires, such as thick bark and the ability to resprout from the base of their trunks (Howard 1992, Fry 2008), though mature oaks are vulnerable during high intensity fires. Periodic low-intensity fires can promote oak survival by killing pathogens, increasing the availability of nutrients in the soil, and reducing the risk of larger future fires (Pavlik et al. 2002, Purcell and Stephens 2005, Holmes et al. 2011). For information about reducing fire risks when landscaping with oaks, see guidelines from CalFire (www.readyforwildfire.org) and the California Native Plant Society Fire Recovery Guide (CNPS 2019).

Ecosystem Structure and Composition

While this spatial strategy focuses on valley oak, which greatly outnumbered other tree species in Napa and Sonoma valleys historically, other oak species are appropriate in some settings (Dawson 2008, Grossinger et al. 2012). For example, restoration of black oak may be appropriate on the western sides of the valleys (northeast-facing slopes), which tend to be cooler and wetter, while blue oak could be a restoration target on the eastern sides of the valley (southwest-facing slopes), which tend to be hotter and drier (Jake Ruygt pers. comm.).

Restoring other plant species found in oak ecosystems is also a key step to successfully re-oaking. In riparian areas, oaks are often co-dominant with species such as willow (*Salix* spp.) and walnut (*Juglans californica*). In oak savannas, the understory was historically dominated by native grasses and wildflowers, and was kept relatively free of woody vegetation by frequent burning by native Californians (Grossinger et al. 2012). Re-establishing these species will be crucial to recreating functioning oak ecosystems.

In addition to large oak trees, younger trees, oak snags, fallen branches, leaf litter, and rock outcrops should be retained where feasible, as they provide habitat for a wide range of species (Spotswood et al. 2017)

Towards a Regional Approach

Though there has been a large loss of oaks in the North Bay over the past 150 years, we have the potential to reverse this decline. The re-oaking spatial strategy presented here is intended to serve as a model for similar strategies for other valleys in the North Bay and elsewhere. The fundamental concepts underpinning the spatial strategy, such as expanding oak nodes and creating oak corridors, are broadly applicable anywhere within the range of valley oak.

To apply this spatial strategy or similar strategies for other locations, the next step is to explore specific re-oaking opportunities. Re-oaking may require raising community awareness of oaks and the various services they provide. Landowners may also require technical assistance or funding to effectively re-oak their properties. With sufficient support, members of the community can coordinate their efforts to plant oaks across the landscape and restore the natural heritage of the North Bay.

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