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Restoration Goals for Oregon White Oak Habitats in the South Puget Sound Region

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Abstract

Our methodology in prioritizing restoration goals in oak habitats was to create a specific value system that targets rare, declining, endemic or oak obligate organisms and the habitat requirements necessary to ensure their survival. This system must be established and applied in order to set management priorities between and within stands, define specific restoration goals, and ensure the preservation of regional biodiversity. Concurrently, we defined seven oak habitat types, both historical and contemporary, based on differences in structure, composition, and prominent processes. Finally, we referenced priority species and taxonomic groups against habitat types that would satisfy those species requirements.

An alternative to value-driven restoration goals is to restore basic ecological processes, such as fire, to the landscape. These processes may then shape and configure restored habitats. Unfortunately, there are several drawbacks with this technique given current conditions. Within fragmented ecosystems, available habitats may be too small for the ecological processes to operate as projected. This is especially true of processes that work over larger scales, such as fire and grazing. Additionally, the habitats formed may not support priority species that may require specialized habitats.

Specific habitat requirements for the priority species of South Puget Sound oak woodlands were developed through a review of the literature, discussions with experts and analysis of oak stands known to contain priority species. The analysis of oak stands included field surveys of stand composition and structure and the ecological processes present. The specific habitat requirements for each of the priority species vary tremendously. In examining two rare plants this variance is well demonstrated. *Aster curtus* requires open, xeric habitat with at least 50% native bunchgrass flora, while *Trillium parviflorum* requires closed, mesic habitat with a well-developed shrub layer.

We separated the historic oak habitats within the South Puget Sound into three distinct types based on differences in structure, composition, and prominent processes. These habitat types include oak savannas and open woodlands, riparian oak woodlands, and wetland oaks. Being dependent on a short fire interval, savannas and open woodlands (5-100 stems/hectare) have become the most rare oak habitat type in the South Puget Sound.

For additional oak habitat types, mixed oak/conifer woodland, range oak woodland, dense oak woodland and clumped oak have resulted primarily from modifications of the landscape

following European settlement. All of these habitat types were historically absent or rare, occurring only under unique conditions.

Two major points are evident from the integration of habitat requirements of priority species with the characteristics of oak habitat types. First, a variety of oak habitat types are needed to meet biodiversity conservation goals. No single habitat type will meet all goals. A mosaic of oak habitat types within the larger landscape are needed to conserve the biodiversity values of these ecosystems. Second, even within habitat types, the specific habitat requirements of priority species may require special restoration goals.

This document provides biologists, land managers, and other concerned parties with a conceptual framework with which to understand the ecological values of Oregon white oak habitats and the priorities for their conservation. This document also facilitates the active restoration of oak habitats throughout the region by providing a value system that targets rare, declining, endemic or oak obligate organisms and the habitat requirements necessary to ensure their survival.

Introduction

Oregon white oak (*Quercus garryana*) habitats are critical components of the regional biodiversity of the South Puget Sound region. Historically, oak habitats covered over 40% of the South Puget Sound region. These oak woodlands and savannas harbored a unique assemblage of plant and animal species, including a range of species now considered rare or endangered with extinction.

The western gray squirrel (*Sciurus griseus*), an oak-obligate species, was once common throughout the South Puget Sound; now it occurs on only a portion of Ft. Lewis and McChord Military Installations. The status of the western gray squirrel has declined sufficiently that the State of Washington considers it to be threatened with extinction. Another mammal considered threatened with extinction is the Mazama pocket gopher (*Thomomys mazama*). This small rodent is limited to grasslands and oak savanna habitats where it forages underground for roots and the tubers of wildflowers.

Two rare plant species also occur in oak woodland habitats in the South Puget Sound. *Aster curtus* is a small sunflower that forms small colonies of plants in grasslands and open oak woodlands. It ranges from Oregon to Vancouver Island, though the majority of populations are in the South Puget Sound region. In contrast, *Trillium parviflorum* occurs in dense oak woodlands adjacent to streams and wetlands. Both of these plants are listed as sensitive by the State of Washington.

Oak habitats throughout the State of Washington have been identified as priority habitat for neotropical migrant birds. These birds migrate from Central and South America to Washington to raise their young. They include a variety of song birds, such as the western tanager (*Piranga ludoviciana*), several warblers, western wood-pewee (*Contopus sorididuls*) and the western bluebird (*Sialia mexicana*).

Many other organisms exist preferentially in the oak habitats of western Washington. Some of these organisms, such as the western pond turtle (*Clemmys marmorata*) and other amphibians and reptiles, are rather well studied. Other organisms, such as cynipid gall wasps and epiphytic lichens and mosses are not as well understood. Yet all

of these organisms are dependent on oak habitat in the South Puget Sound.

Unfortunately, much of the oak habitats have been eliminated or degraded throughout the South Puget Sound. Since European settlement, over half of all oak habitat has been eliminated. The major causes for this elimination, land conversion and development, continue in the present day.

Degraded oak habitats are often missing key ecological processes, especially frequent and regular fire and oak regeneration. Individual stands of oak are often isolated from other oak habitats, limiting the chance for organisms to move between stands. Some stands are also missing key species, such as the Mazama pocket gopher, which creates small soil disturbances where wildflowers can freely germinate. Finally, many oak habitats are degraded by human uses such as firewood cutting, livestock grazing or off-road vehicle activity.

The continued decline of oak habitats will result in the extirpation of threatened, endemic, and oak obligate species. Conservation of oak habitats and associated species requires active management and restoration. Through controlled burning, conifer removal, and other processes, oak habitats can be revitalized. In the absence of intensive management, oak habitats will continue to decline.

The disturbance-based ecology of oak habitats provides an excellent lesson: that conservation is not limited to preservation. Not only does successful conservation require habitat protection, but it often requires intensive and thoughtful human participation.

Historic Conditions

The oak habitats of the South Puget Sound region are built on a foundation of poor, gravelly soils. These soils were deposited at the end of the last Ice Age, 15,000 years ago, when the Vashon glacier retreated. The outwash from this glacier was deposited in a broad path from Tacoma to the southwest through the Chehalis River valley. This outwash consisted primarily of coarse deposits and formed soils that are well-drained and nutrient poor.

Summer droughts, combined with burning by Native Americans, created conditions suitable for oaks and prairie grasslands. These habitats, along with wetlands, riparian forests and patchy coniferous forests, formed a mosaic of open habitats throughout the region.

Within the landscape mosaic, oak habitats often formed at the ecotones between other habitats, especially grasslands and either conifer forests, riparian corridors, or wetlands. Certain species of plants and animals require the varied resources and processes offered by specific ecotones. For example, western gray squirrels require the presence of oaks, large conifers, and a water source all in close proximity.

The historic oak habitats within the landscape mosaic can be separated into three distinct types based on differences in structure, composition, and prominent processes. These habitat types include oak savannas and open woodlands, riparian oak woodlands, and wetland oaks. Each is described below.

<u>Oak savannas and open woodlands</u> - Oak savannas and open woodlands were dominated by large, mature, widely spaced oaks with single trunks and broad, spreading crowns. The understory was a single

herbaceous layer of native bunchgrasses and forbs. Oak savannas and open woodlands were common historically, but are almost entirely absent from the South Puget Sound region today. Only small patches of these habitats remain in South Puget Sound, but no large, continuous stands are present as historically described.

Savannas and open woodlands were maintained primarily by fires set on a near-annual basis by Native Americans. Fire perpetuated these habitats by inhibiting the reproduction of invasive woody species, particularly Douglas-fir (*Pseudotsuga menziesii*). Oaks and herbaceous grassland species tolerated this frequent burning because of fire resistant bark and the ability to resprout from deep tap roots, respectively. Conifers were more susceptible to fire and were rarely able to reach fire-safe size. Both oaks and conifers that achieved fire-safe sizes resisted the regular, low-intensity fires and grew to maturity. Therefore, tree populations were composed primarily of mature individuals.

The majority of grassland and savanna fires were intentionally set by native tribes to maintain food resources. These fires appear to have been of low intensity and set semi-annually over the majority of the landscape. Food staples enhanced by fire included acorns and the bulbs of the camas lily (*Camassia quamash*) and chocolate lily (*Fritillaria lanceolata*). Fire was also used to maintain and concentrate game populations by limiting areas of unburned forage and by producing fresh regrowth of forage following fires.

Riparian oak woodland - Mesic areas along streams and creeks were less affected by fire and expressed composition and structure quite different from savannas and open woodlands. Riparian oak woodlands had variable structures, but most often were in thin, linear bands, forming an ecotone between grassland and seasonal or year-round watercourses. The variable structure and composition of this habitat type was primarily due to differences in the fire frequency of particular microsites, but also to the presence or absence of conifers. The most typical overstory structure consisted of thin, tall oaks that formed a closed canopy, slightly upland from more moisture-tolerant tree species. In general, age classes and densities of oaks were wide ranging. The understory consisted of diverse shrub and herb layers, with a much greater occurrence of mosses, ferns, and coarse woody debris than savannas and open woodlands.

Historically, this habitat type experienced fires on a sporadic interval due to fluctuations in microsite moisture levels. Oaks in this habitat type endured both moderate summer drought conditions and occasional winter flooding.

Riparian oak woodlands are a common habitat type both in historical descriptions and presently. In the 170 years since European settlement, however, this habitat type has changed considerably. The introduction of alien species and fire suppression have led to denser stands with understories containing a high proportion of invasive species.

Wetland oak - Consistently mesic soils, proximity to wetland edges, typically small area, and unique species composition distinguished wetland oak from riparian oak woodlands. Similar to riparian oak woodlands, wetland oaks grew tall and thin and formed a generally closed canopy. However, shrub diversity and coverage were much higher than in riparian oak woodlands. The herb layer, therefore, consisted primarily of shade-tolerant species, such as *Trillium parviflorum* and sword fern.

Due to mesic conditions, fire played a role in this habitat type only in extremely dry

seasons; fire intervals were much longer than in other habitat types. Oak reproduction was probably sporadic in this habitat type, having been most active following disturbances such as fire.

The ecological character of this habitat type has changed relatively little over the last 170 years. Surrounding communities are often subject to succession by conifers, but, due to the mesic soils that exclude most conifers, oaks can persist in this habitat type for long periods. If no disturbances, such as tree removal or fire, occur for hundreds of years, oaks will be succeeded by faster growing species such as Oregon ash (*Fraxinus latifolia*) and big-leaf maple (*Acer macrophyllum*).

Current Conditions

A variety factors have contributed to the decline and degradation of historic oak habitat types. The most severe and lasting impacts have been caused by land conversion and development, fire suppression, introduction of invasive pest plants, oak removal, and grazing.

The most immediate and irreversible threats to oak habitats are land conversion and development. Both lead to loss of oak habitat and to fragmentation of quality habitats within the regional landscape. Conversion for agriculture, timber production, and range land has occurred consistently since European settlement began and continues to eliminate and fragment remnant habitat. Development of all types (dwellings, roads, etc...) continues to spread to the more rural areas of the region, removing and degrading quality habitats in the process.

The most significant problem within oak habitats spared from development has been fire suppression. Oaks benefit from regular and frequent fire intervals through the reduction in competition from other less fire-resistant woody species. In the absence of fire, oak habitats have been especially susceptible to invasion by conifers. Douglas-firs that achieve more than 3m in height, approximately 10 years growth, are able to withstand low to medium intensity fires (Sugihara and Reed 1987). Douglas-fir is the most competitive and common invading conifer, though grand fir (*Abies grandis*) can also out-compete oaks, especially on wetland and riparian edges.

Another problem associated with fire suppression is a general increase in oak stand density. The continuum of oak habitat types in pre-settlement varied from sparse savanna to dense thicket. During the last 170 years, surviving savannas and woodlands have filled in with younger oaks, becoming more dense. The result has been an almost complete loss of savannas and an increase of both stem density and coverage within oak habitats. Current oak habitats on Ft. Lewis, for example, have an average of 93 trees per acre, as opposed to 8 trees per acre in 1853 (Public Forestry Foundation, 1995). Increases in stem density and coverage lead to changes in understory composition and structure and eventually to a reduction in the diversity of habitat types.

The introduction and proliferation of invasive pest plants is a continuing threat within oak habitats. The most noticeable and harmful invasive species is Scotch broom (*Cytistus scoparius*). This species is an aggressive, habitat-modifying shrub that can displace native understory communities in a matter of years. It is prolific, fast growing, and difficult to remove. A host of invasive grasses and forbs are also present in oak habitats. Over a periods of decades, these species displace native understory communities, particularly in the absence of fire.

A problem present since the early days of settlement has been the direct removal of oaks. The fate of the vast majority of old-growth oaks, especially larger savanna trees, was as fuel wood, fence posts, and utility lumber, especially for pallets and casks. The relatively slow growth rate of oak inhibits the potential for regeneration; consumptive harvest easily outpaces oaks' ability to recover. With the majority of stands in private ownership, oaks continue to face the same threats.

Intensive grazing has occurred in oak habitats for over 170 years and continues on many privately owned stands. Problems associated with consistent grazing lead to declines in oak habitat quality. Native shrubs and small trees, for example, are often heavily browsed or trampled. As well, to increase the production of forage, invasive pasture grasses are introduced. Combined with the disturbances associated with trampled and soil compaction, these grasses quickly displace native understory communities. These factors combine to have a strong negative effect on both understory diversity and oak reproduction.

The preceding processes have caused the structure and composition of historic oak habitat types to be considerably modified from historic conditions. Four additional oak habitat types, mixed oak/conifer woodland, range oak woodland, dense oak woodland and clumped oak have resulted from these modifications (Figure 1). All of these habitat types were historically absent or rare, occurring only under unique conditions. Each is described below.

Mixed oak/conifer woodlands - Mixed oak and conifer woodlands can be found adjacent to any of the habitat types described. Oaks and conifers, most commonly Douglas-fir, are present in a wide variety of ages and growth forms with the vast majority less than 100 years old. In most cases conifers are actively suppressing oaks by overtopping and subsequent light deprivation. The density and age of the conifers determines, in large part, the structure and composition of particular sites. As conifers overtop oaks and establish dominance, soils become more mesic and acidic. Under these conditions species composition of both plants and wildlife can change considerably towards those typical of conifer forest.

Mixed oak and conifer woodlands exist under conditions of moderate summer drought and fire suppression. As fire suppression continues, firs succeed and eliminate oaks. Both sexual (seedlings) and asexual (clones) oak reproduction appear active in more open microsites within these habitats. Canopy closure by fir, however, eliminates all oak reproduction.

Range oak woodlands - Range oak woodlands can be found adjacent to any of the habitat types described, but are most often found within agricultural landscapes. Tree density, growth form and age are variable in these habitats, though only larger trees (>10 cm dia.) are able to resist heavy browsing and trampling. The shrub layer is minimal in these habitats due to browsing and trampling. The herb layer is dominated by invasive grasses; native herbs typically persist in small populations.

Range oak woodlands exist under conditions of moderate summer drought, fire suppression, and varying degrees of browsing and trampling by livestock. All oak reproduction in this habitat type is suppressed due to browsing and trampling.

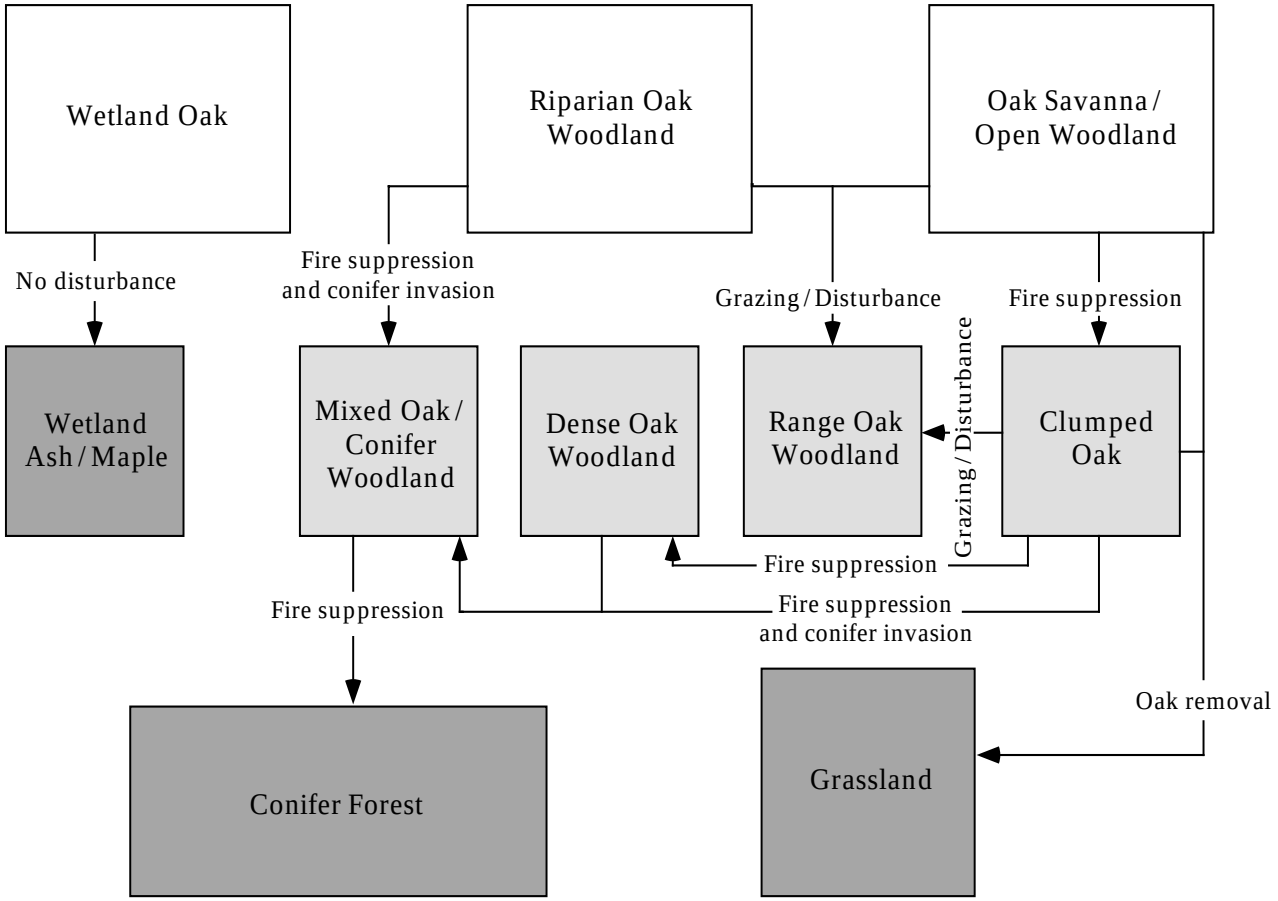

Figure 1- A conceptual model of disturbances within Oregon white oak habitat types in the South Puget Sound. White boxes indicate historic oak habitat types; light gray boxes indicate altered oak habitat types; dark gray boxes indicate non-oak habitat types.

Dense oak woodlands - Dense oak woodland can be found adjacent to or within Story oaks in this habitat type are numerous With the majority typically less than 100 years old. These densely spaced trees are typically thin due to heavy competition, and form a closed canopy. A small number of large, older trees may also be present. The understory is variable in structure and contains native and invasive shrubs and herbs. Two species, Scotch broom and snowberry (*Symphorocarpus albus*), dominate the understory.

This habitat type is the result of the relatively recent suppression of a fire interval or of recent oak colonization. It exists under conditions of moderate summer drought and fire suppression. Reproduction is both sexual and asexual, but may be hampered by canopy closure. If adjacent to grasslands, oak reproduction primarily occurs at the grassland edge.

Clumped oak - Clumped oak occurs adjacent to grasslands and derives from oak savanna that has undergone suppression of a fire interval. Young oak clones surrounding one or more parent trees are able to surpass fire-safe size and form a small stand with a closed canopy. The composition of clumped oak is similar to that of dense oak woodlands.

Clumped oak exists under conditions of summer drought and fire suppression. Sexual reproduction is reduced due to competition from herbs and shrubs, while asexual reproduction remains unaltered. any of the habitat types described previously. Over-
Oak clones have a large competitive advantage over oak seedlings because of the well-developed root systems of parent trees. This accounts for the relatively rapid rate by which oak savanna can convert to clumped oak.

Restoration of Oak Habitats

"The primary goal of ecological restoration is to renew the health of converted ecosystems..." (Society of Ecological Restoration, 1996). If this 'primary goal' were to be followed ideally, all oak habitats in the South Puget Sound region would be restored to a state of 'health'. Unfortunately, the realities of limited resources demands that priority restoration goals be established. Therefore a second, more specific set of restoration goals is needed.

Identifying a specific value system for restorations associated with The Nature Conservancy is not difficult. The fundamental mission of The Conservancy is, "to preserve plants, animals and communities...by protecting the lands and water they need to survive" (The Nature Conservancy, 1993). Therefore our task is to identify rare, endemic or declining organisms as restoration goals and ensure their survival by identifying their habitat requirements. The habitat requirements of these relatively rare species then become targets for restoration.

Table 1. Known habitat requirements of priority species and taxonomic groups utilizing Oregon white oak habitats in the South Puget Sound

Species	Habitat Requirements
Plants and Epiphytes	
White-top aster (*Aster curtus*)	> 50% cover of native grassland species on xeric soils. Partial to open oak canopy.
Sessile trillium (*Tillium parvifolium*)	Dense, native-dominated shrub layer on mesic soils. Closed, oak canopy.
Oak epiphytic lichens & bryophytes	Highly variable; extreme xeric and mesic locations. Probably most critical for maintaining diversity.
Wildlife	
Propertius' duskywing (*Erynnis propertius*)	Juvenile oak for larval development.
Northwestern pond turtle (*Clemmys marmorata*)	Open oak woodland/prairie adjacent to watercourses.
Lewis' woodpecker (*Melanerpes lewis*)	Open oak or pine woodland; preference for regularly Burned habitats. Needs larger snags for nesting.
Western wood-pewee (*Contopus sordidulus*)	Large horizontal oak branches for nesting.
Slender-billed nuthatch (*Sitta carolinenis*)	Oak savanna or edges with larger snags (or nest boxes) for nesting.
Western bluebird (*Sialia mexicana*)	Oak savanna or edges with larger snags (or nest Boxes) for nesting. Hunting perches provided by Savanna oak or substitute.
Western gray squirrel (*Sciurus griseus*)	Mixed oak/conifer habitat with a diversity of other food producing trees and shrubs. Stand must also be >2 ha and <.6(1) km from a year-round water source.
Mazama pocket gopher (*Thomomys mazama*)	>50% cover of native grassland species on xeric soils. Open oak canopy.

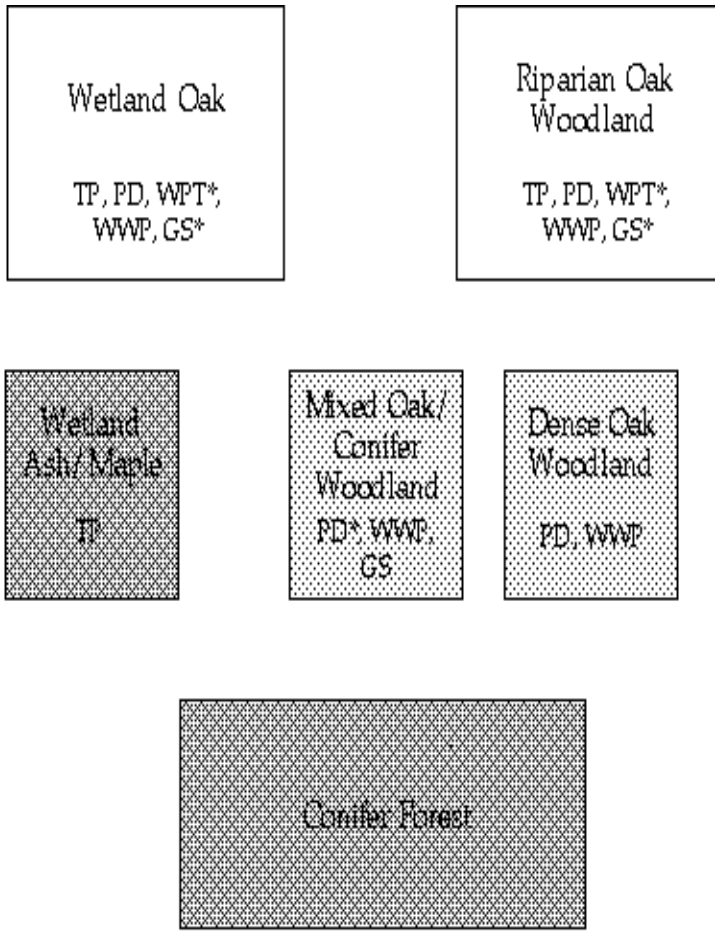

Figure 2- A conceptual model of priority species usage within Oregon whit
White boxes indicate historic oak habitat types; light gray boxes indicate alt
non-oak habitat types.

AC: White-top aster, TP: *Trillium parviflorum* PD: Propertius' duskywing, W
woodpecker, WWP: Western wood-pewee, SBN: Slender-billed nuthatch, W
PG: Mazama pocket gopher.
* indicates possible species usage or usage under specific conditions (see T

Specific habitat requirements for the priority species of South Puget Sound oak woodlands were established through a review of the relevant literature, discussions with experts and analysis of oak stands known to contain priority species (Table 1). The analysis of oak stands included field surveys of stand composition, structure and ecological processes present. The specific habitat requirements for each of the priority species vary tremendously. Of the rare plants, *Aster curtus* requires open, xeric habitat with at least 50% native bunchgrass flora, while *Trillium parviflorum* requires closed, mesic habitat with a well-developed shrub layer.

All oak habitat types can potentially benefit one or more priority species, though some habitat types are clearly more critical for

preserving regional biodiversity (Figure 2). The majority of priority species are associated with the extremes of the habitat types, either the wetland associated oaks or the dry oak savanna and clumped oak. Riparian oak woodland can also support a range of priority species, especially when it abuts other critical habitats. For example, the western pond turtle could be reintroduced to riparian oak habitats if suitable aquatic habitat, slow moving streams with significant pools and eddies, is within 250m.

Unfortunately, degraded habitat types such as the range oak woodland and mixed oak/conifer woodland support few priority species. Range oak woodlands do support certain bird species, especially those that forage in the canopy. The value of mixed oak/conifer woodlands depends on the density and size of the conifer component; when conifers dominate a stand, few oak values are present.

When the habitat requirements of priority species are integrated with the characteristics of the various oak habitats, two major points become evident. First, no single habitat type will meet all goals; a mosaic of oak habitat types within a larger landscape are needed to conserve the biodiversity values of these ecosystems. Second, even within habitat types, the specific habitat requirements of priority species may require special restoration actions.

Restoration Pathways and Techniques

A variety of restoration pathways and techniques for Oregon white oak habitats are possible. These pathways are essentially a reversal of the degradation pathways described in Figure 1. Each of these pathways and techniques has particular advantages and difficulties. Although a comprehensive discussion of these pathways and techniques is beyond the scope of this paper, several principles are evident and are discussed. Specific information on oak habitat type parameters, priority species habitat requirements, individual stand data and management techniques is available on request through the Nature Conservancy of Washington.

Restoration pathways that involve the reduction of the canopy are easier to conduct than those that increase the canopy. Oregon white oak grows slowly and requires several decades before reaching maturity. The growth of a tree to a size large enough to support cavity nesting can take up to 150 years. This slow growth prolongs the restoration process, straining support and resources. Additionally, pest plant problems can persist until canopy closure; management efforts associated with pest plant control may need to continue for several decades while oaks mature. We should, therefore, concentrate on restoring remaining oak habitats, rather than relying on the creation of new habitats.

Reduction of the canopy can include removing select oaks from dense oak woodlands, conifers from mixed oak/conifer woodlands, or other deciduous species from wetland or riparian areas. Removal of unwanted trees can be accomplished using traditional or slightly modified forestry methods. Traditional methods are acceptable when the understory is already degraded and not a priority for restoration. When protection of the understory is critical, alternative techniques, such as helicopter logging, can be utilized.

Restoration of understory, especially native grassland, is possible but can be resource and personnel intensive. Transplantation of understory seedlings is a proven technique, but costs can eliminate its use on larger projects. Shrubs may be planted in wetland

and riparian stands to restore structure and shade out pasture grasses. Evaluation of the specific restoration goals for the stand can help determine if the restoration of a native-dominated understory is required.

Invasion and establishment of pest plants into existing oak stands is a significant problem for restoration around the South Puget Sound. Opening dense oak woodland promotes Scotch broom invasion, while frequent burning and soil disturbances may promote other weeds. These pest problems need to be addressed in the restoration and continuing management plans. If required, restoration goals should be modified to match the management resources available for pest plant control.

Landscape Considerations

Proper planning for restoration of oak habitats needs to consider factors beyond individual stands. These landscape-level considerations are important if the restoration goals are to be achieved over the long-term. Three landscape level considerations are especially pertinent for oak restoration: habitat fragmentation, viable regional populations and adjacent habitats,.

Habitat Fragmentation- Oak habitats in the south Puget Sound region are extremely fragmented. Stands of oaks are usually isolated, increasing the likelihood of the local extinction of plants and animals, and reducing the ability for animals to colonize between stands. Oak stands are also often widely scattered and small in size, with little natural habitat between stands.

To a certain degree, fragmentation is a natural characteristic of oak habitats. However, the degree and intensity of isolation currently occurring is beyond the effects of natural fragmentation. Interaction between stands has diminished, with the most severe consequences affecting plants and animals that cannot disperse long distances. The negative effects of fragmentation are magnified when ecological processes such as burning are applied to small stands; an already small population may not be able to recolonize following a burn. Rare plants, butterflies and other invertebrates suffer the most from the compounding of fragmentation and large-scale disturbances such as fire.

Restorations that reduce fragmentation by linking oak habitats, especially larger stands, will be especially effective in reaching regional biodiversity goals. When stands cannot be linked directly, habitats suitable for dispersal of priority species are desirable.

Viable regional populations - An issue closely related to fragmentation is the maintenance of viable regional populations of priority species. For instance, larger animals such as the western gray squirrel require several stands with a particular set of characteristics to maintain a single population. In fact, few isolated oak stands are large enough to harbor sufficient numbers of a priority species to establish independently viable populations. During planning, priority should be given to stands that add potential habitat or dispersal pathways to current populations of priority species with large habitat requirements.

Adjacent habitats - The type and size of the habitats immediately adjacent to an oak stand shapes the structure and composition of the stand. Adjacent habitats are also important since ecological processes, such as burning or managed water regimes, act across habitats. As previously described, oak habitats adjacent to grasslands are affected by the regular fires needed to maintain the open grassland structure. Similarly, oak habitats adjacent to wetlands

or streams are less affected by fire, and exhibit a denser canopy with a shrub understory.

Adjacent habitats can have negative effects on the plants and animals of oak woodlands. For instance, adjacent roads can be major mortality sinks for several types of wildlife. Significant losses to a population can occur if the habitat is small and dispersal paths are limited to crossing roadways or developed areas.

Goal planning must include consideration of the influences of existing adjacent habitats. The western gray squirrel again provides an excellent example. Within an individual's home range it requires no human development, a large oak stand, mature conifers for nesting and a year-round water supply. If few of these requirements exist at a particular site, and can only exist via a colossal input of resources, then planning for the reintroduction of squirrels would be wasteful and ineffective.

Summary

Oak restoration in the South Puget Sound region is a complex process that requires thoughtful and intensive long-term efforts. Careful goal planning is the most effective tool in making restoration successful. The value system that focuses on the habitat requirements of priority species allows for very specific and targeted goal planning. The presence or absence of particular stand characteristics can determine which species or habitat types are most reasonable to work towards. The informed selection of a set of goal species and target habitat types will significantly reduce long-term management efforts; choose goals that are attainable and make the best possible use of land and resources.

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