Impact of Declining Oak Woodlands on Missions:

Oak Woodland Restoration on McChord Air Force Base

Submitted to:
McChord Air Force Base
62 CES/CEVN

Prepared and Submitted by:
The Nature Conservancy of Washington
November 15, 2000

Table of Contents

Introduction

A Subagreement pursuant to delegation authority contained in the Cooperative agreement between the Department of Defense and The Nature Conservancy (TNC) dated 13 December, 1988 was entered into by McChord Air Force Base (AFB) and the Washington Field Office of The Nature Conservancy in July of 1993. This subagreement calls for the inventory and mapping of ecosystems and species of concern as well as the performance of such tasks as may be outlined in specific Study Authorizations submitted by McChord AFB.

A Study Authorization titled "Impact of Declining Oak Woodlands on Missions" has been developed and was entered into in August of 1995. It calls for the design and implementation of appropriate management techniques for the restoration and maintenance of Oregon white oak and associated ponderosa pine vegetation communities on McChord AFB. This final report covers work conducted from September 15, 1995 to September 15, 2000.

Background

The native prairie, woodland, wetland and forested ecosystems of the Puget Sound region in western Washington currently occupy only a small fraction of their original extent. As a result, many of the native species and natural communities that inhabited this region have become rare or are threatened with extinction. While much of the land that makes up McChord AFB has been significantly altered, some portions exist in a condition that approximates the original landscape.

Prior to this Study Authorization, five prior studies were in place or completed between The Nature Conservancy and McChord AFB, which are pertinent to this project. The purpose of these studies was to determine the locality and significance of sensitive species and habitats on McChord AFB, including specifically oak woodlands, pine communities and their associated species. These Study Authorizations are 1) Species of Concern; 2) Amphibians and Reptiles; 3) Wetlands and Sensitive Habitats; 4) Neotropical Migratory Birds; and 5) Moths and Butterflies. Final reports for each of these studies have been completed and accepted by the environmental program of McChord AFB.

Objectives

The primary objectives of the Impact of Declining Oak Woodlands on Missions: Oak Woodland Restoration on McChord Air Force Base Study Authorization include:

A. Investigation and determination of desirable ecological conditions within Oregon white oak and associated ponderosa pine stands.

B. Determination of feasible long-term oak and pine management techniques on McChord AFB.

C. Experimental design for restoration treatments, monitoring and data collection activities on McChord AFB.

D. Identification of appropriate sites on McChord for application of restoration techniques and implementation of restoration actions, monitoring and data collection.

Report of Findings

Restoration and Management Actions

Sites

Restoration and management actions centered on four sites, which represent a range of oak stand conditions and configurations on McChord AFB (Table 1). The stands range from mature closed canopy oak woodlands, Skeet Range, to open young oak woodlands, Morey Pond and Bensten Wetland. In addition, one stand, 300 Area, contains significant amounts of ponderosa pine. The major threat to these stands is the invasion and establishment of pest plants. These pests include the invasion of the native tree, Douglas-fir, the non-native shrub, Scotch broom, and sod-forming grasses like tall oatgrass. The other major threat is altered understory composition, especially reduction in species that are necessary for rare species like prairie dependent butterflies.

Location	Habitat Type	Major Threats
Skeet Range	Closed-canopy Garry oak woodland	Douglas-fir, Scotch broom, sod-forming grasses
300 Area	Garry oak, ponderosa pine, Douglas-fir woodland	Douglas-fir, Scotch broom
Morey Pond	Open-canopy Garry oak woodland	Scotch broom, sod-forming grasses, understory composition
Bensten Wetland	Open-canopy Garry oak woodland Garry oak-conifer mosaic	Douglas-fir, Scotch broom, sod-forming grasses, understory composition

Three of these sites occur on the main base and one within the South Approach Zone (Fig 1). Due to the nature of prior development on McChord AFB, each site is small and relatively isolated from other habitat patches. The exception is Bentsen Wetland, which occurs within the South Approach Zone. This zone forms a larger habitat mosaic of oak woodlands, wetlands and coniferous forests. These habitats are contiguous with similar habitat on the adjacent Ft. Lewis.

Despite their size and isolation, each of the chosen sites is exceptional in current or potential characteristics. The composition and structure of an oak stand largely determines the habitat

quality of the stand for species of concern. Oak woodland with a solid canopy of oak will harbor different species than an open oak savanna with grassland (Fig. 2). The oak stands found at the Skeet Range, 300 Area, Morey Pond and Bentsen Wetland are different in many ways as a result of environmental conditions and their past histories. The likely alternative future conditions for each of the stands is also somewhat different. Brief verbal descriptions of each site are given below along with alternative future conditions. In-depth descriptions of the vegetation on each site are given in Appendix 1.

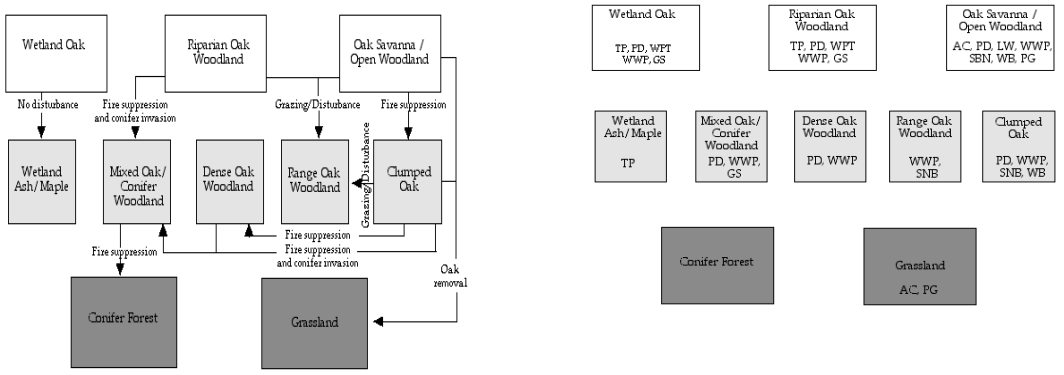

Fig 2. Oak woodland models – ecological processes and conservation targets. Priority species usage is illustrated in the figure on the right. Abbreviations for species are: AC: White-top aster, TP: Trillium parviflorum, PD: Propertius' duskywing, WPT: Western pond turtle, LW: Lewis' woodpecker, WWP Western wood –peewee, SBN: Slender-billed nuthatch, WB: Western bluebird, GS: Western gray squirrel, and PG: Mazama pocket gopher.

The Skeet Range is oak woodland with a high density of larger oak trees that form a closed canopy (Fig. 3). Grasses, herbs and native shrubs dominate the understory. Scotch broom only appears where the canopy opens up and along the edges of the stand. Douglas-fir invasion is present along the margins of the stand and is overtopping oaks in this area. The oak woodland in the Skeet Range should be maintained in its current condition, with improvements to understory in open areas and removal of key overtopping Douglas-fir. Additional expansion of the oak woodland into the open areas could be conducted once Scotch broom is controlled in those areas.

Both Oregon white oak and ponderosa pine habitats are found in the 300 Area (Fig 4). The oak stand is in a woodland form with a tall shrubby understory. Adjacent to the oak is a stand of ponderosa pine that is mixed with Douglas-fir and oak. The pine becomes quite open in areas and contains native grassland species in the understory. Scotch broom and Douglas-fir invasion was quite prevalent in many parts of this area. The control of these threats is an important part of restoration efforts. Neotropical migrant birds will benefit from the control Scotch broom, while butterflies may increase if grassland species are promoted.

Fig. 3. The Skeet range oak woodland, showing high density of oaks with grass understory, Summer 2000.

The oak habitats at Morey Pond and Bensten Wetland are quite similar. Young oak trees are found as clumps or widely spaced. Most oaks are approximately 30 ft. or less in height and less than 20 inches in trunk diameter. Douglas-fir has invaded some areas and young fir are found throughout the stands. Understory vegetation is a mix of Scotch broom, native shrubs and native or non-native herbs and grasses. Wildlife diversity in these areas is quite high and many neotropical migrants and sparrow species can be seen. Because the areas are already in an oak savannah form they offer the greatest opportunity on McChord AFB to restore this natural oak habitat type. Oak savannas have been largely lost from the South Puget Sound because of fire suppression and disturbance. Neotropical migrant birds would benefit from the control of Scotch broom; sparrows, including Oregon vesper sparrow, and butterflies should increase when native grassland species are promoted.

Actions

Restoration actions on the McChord AFB sites concentrated on alleviating biological threats and enhancing habitat for rare species. The majority of work focussed on controlling Scotch broom, the most serious threat at most sites. Other significant tasks included removing Douglas-fir that directly interfered with oak trees, targeted enhancement of the woodland understory, and planting of oak seedlings.

Controlling Scotch broom requires effectiveness and persistence. Control efforts need to be effective, since Scotch broom can be difficult to kill. Young plants can resprout from their base when they have been cut. Cutting Scotch broom just prior to or during our summer drought period can minimize this resprouting. Alternatively, control with chemical herbicides is also effective in killing Scotch broom.

Scotch broom control efforts must be persistent due to this resprouting and more importantly, due to a long-lived seed bank that can consist of millions of seeds and produce new plants for years after a successful control effort. The seeds of Scotch broom can survive for decades in the soil and this seed bank can continue to produce seedlings of Scotch broom at high densities for several years. An effective control program therefore requires multiple control actions over a period of 5-10 years or more.

For the oak woodland sites at McChord AFB a combination of mechanical and chemical control efforts was completed. Mechanical control through cutting with hand-held brushcutters or tractor-mounted rotary cutter was used initially. These initial control efforts were especially effective since many of the plants had not been cut previously and were rather old, characteristics that lead to effective control with mechanical cutting. But resprouting and germination from the seed bank have required follow-up control. At most sites mechanical control was continued, though chemical control was used on portions of two locations, Skeet Range and 300 Area.

Fig 4. 300 Area contains both Ponderosa Pines and Oregon White Oaks along with grassland understory, Summer 2000.

Chemical control was used in areas where germination from the seed bank was high and the understory contained few native species. This allowed the application of herbicides effective on Scotch broom without damaging native species. The herbicide used was Garlon 3a, with the active agent triclopyr. This herbicide only affects broad-leaved plants and is recommended for Scotch broom by the Northwest Weed Handbook. All herbicide applications were conducted by licensed herbicide applicators.

Douglas-fir control was limited to those trees that were directly overtopping significant oak trees and small trees that were beginning to grow up through the oak canopy. Trees were dropped with chainsaws and the biomass was chipped and removed from the site. Particular care was taken in dropping of larger trees to minimize damage to oak trees. If a mature oak is damaged during this type of operation it may take decades for the tree to recover. Control of Douglas-fir occurred at all sites, though two sites, the Skeet Range and 300 Area, needed the greatest amount of this restoration action.

Enhancement of understory was conducted at the Bensten Wetland site in open areas within the oak woodland matrix. A significant amount of the work was part of experimentation on site preparation and plant establishment methods, which is described later in this report. Additional

work increased the area of enhanced understory using methods developed through the experiment. The site was cleared of Scotch broom, rototilled to eliminate Scotch broom seedlings and non-native pasture grasses and then planted with plugs of native grasses and forbs. The transplanted species are either major components of native grasslands or primary nectar or larval host species for native butterflies (Table 2).

Table 2. Native plant species plugged and direct seeded near Bensten Wetland, McChord Airbase.

Species	Plugged	Seeded	Habitat Value
Grasses			
California oatgrass	X	X	Secondary native grass
Idaho fescue	X	X	Primary native grass / larval host
Forbs			
Bluebells		X	Native forb
Common camus		X	Early spring nectar source
Cutleaf microseris	X	X	Nectar source
Oregon sunshine	X	X	Nectar source
Pomocelery lomatium	X	X	Nectar source / larval host
Prairie lupine		X	Nectar source / larval host
Puget balsamroot		X	Native forb
Showy fleabane	X	X	Nectar source
Slender cinquefoil		X	Native forb
Spikelike goldenrod	X	X	Late season nectar source
Western buttercup		X	Early nectar source
White-topped aster		X	Rare endemic / late nectar source

Two-year old individuals of Oregon white oak were planted into two of the areas on McChord AFB, Skeet Range and Bensten Wetland. Both of these areas had sections of habitat that were not productive as open habitat and were in need of additional canopy trees. These oaks are extremely small, even at two years of age and each transplanted individual had only a few sets of leaves. But transplantation of this size of oak has been successful in other prairie sites, especially when appropriate shading occurs. Each of the transplanted oaks on McChord AFB was shaded with tree shields that should be effective for several years. Once the seedlings grow beyond the top of the tree shields they can then be removed.

Results

The restoration actions applied to the target oak woodlands on McChord AFB had two results. First they improved the basic structure of the woodlands, mainly through the elimination of a undesirable shrub layer. Second, the restoration actions enhance the composition of woodlands.

The Scotch broom control efforts greatly increased the area of effective grassland understory within the oak woodlands. Each of the target woodlands enjoyed periods free of mature Scotch broom, with lush low stature understories (Fig. 4). The Scotch broom control efforts varied in success from very high kill rates to moderate kill rates. This range of effectiveness followed patterns previously determined through restoration efforts on other South Puget Sound prairies and oak woodlands. In general, mechanical control through cutting works best on older, mature Scotch broom, especially when conducted during the summer. Mortality can approach 100% under these conditions. Cutting of younger plants results in lower mortality, but has the secondary effect of limiting the seed produced each plant and the input to the seed bank. Mortality from cutting younger plants ranges from 20 to 50%.

Fig. 4. Results of Scotch broom control at three sites on McChord AFB, 1997. Clockwise from upper left, Skeet Range, 300 Area and Morey Pond.

Controlling Scotch broom with herbicide is extremely effective, with mortality rates of near 100%. Herbicide control is especially important on Scotch broom seedlings and immature individuals. This is especially true when the density of individuals that need to be treated is high. Unfortunately, it is only appropriate where damage to native species can be minimized. Chemical control in the Skeet Range and Bensten Wetland areas were successful in killing entire cohorts of Scotch broom seedlings or slightly larger immature plants.

The structure of the oak woodlands was also improved through the removal of Douglas-fir trees. Most of these trees formed an understory that was a direct threat to the woodland as they grew larger. Elimination of these individuals allowed the oaks to grow freely and hopefully increases the spread of the canopy of individual oaks. This thinning of Douglas-fir will also help to maintain or increase the amount of continuous canopy within woodlands with closed canopy sections. Due to the slow growth of mature Oregon white oaks measurements for the response of the oaks are not meaningful over the study period. Therefore, the direct response from the thinning was not quantified.

The composition of a section of the Bensten Wetland site was enhanced with the direct planting of understory plants. Transplantations were extremely successful with virtually all transplanted individuals surviving. These plants also grew extremely quickly in the tilled soil and produced numerous flowers their first season in the ground (Fig. 5). The transplanted area was a dramatic improvement over the starting conditions. Unfortunately, direct seeding of prairie plants was not as successful. Further discussion on both transplanted and seeded species can be found in the section on the transplantation experiments.

The transplanted oak trees are surviving and growing well. All individuals have survived and produced new growth. Some individuals will nearly reach the tops of their protective tree tubes next year.

Discussion

The restoration actions completed through this program have substantially improved habitat conditions within the target oak woodlands. The structure changes resulting from Scotch broom and Douglas-fir control are known to result in increases in bird and plant diversity. If these benefits are to be continued into the future then on-going maintenance of the areas needs to be implemented. The oak woodlands of South Puget Sound need active, on-going management if they are to be maintained in good ecological shape. The restoration actions taken in this project have reversed significant amounts of degradation, but persistent efforts must be implemented if these benefits are not to be lost.

The on-going management of the target habitats should first focus on the biological threat of Scotch broom. Unfortunately, new seedlings will continue to sprout from the seedbed for many years to come. If these seedlings are not controlled, then mature plants will once again replenish the seed bank and maintenance will be more difficult. Yearly management of the sites can utilize the techniques used during the restoration actions to continue a Scotch broom control program. Scotch broom control techniques should match the status and development of the Scotch broom at each site (Table 3.)

Table 3. *Efficacy of recommended control techniques for different ages of Scotch broom.*

	Seedlings	**Young**	**Mature**	**Old**

		(1-2 yrs.)	(3-5 yrs.)	(> 5 yrs.)
Prescribed Fire	**Yes**- Requires sufficient fine fuels interspersed in broom seedlings.	**Yes**- Resprouting is common, especially with spring burns.	**Yes** – Burning earlier in this stage minimizes seed bank. Resprouting is common.	**Yes** – Stimulates seed bank, which can be a positive or negative characteristic.
Mechanical	**No**	**Yes** – Hand-pulling or weed wrench is viable if numbers are low.	**Yes** – Resprouting is common, but can be used to minimize seed production	**Yes** – Best when plants are stressed. Mortality can be high. Good preparation for future prescribed burn.
Chemical	**Yes** – Backpack spraying of limited-sized patches.	**Yes** – Spraying in late summer/early fall can minimize effects of drift on native forbs.	**No** – Foliar sprays require larger amounts of herbicide. Treat mechanically and follow with chemical or fire.	**No** – Other treatments are effective with less side-effects.

The understory enhancement at Bensten wetland site should continue to expand the area of improved understory. About of an acre of habitat has been enhanced. This area should be enlarged as part of on-going management efforts. Transplantation of pure stands Idaho fescue should be considered first, since other non-target plant species can be controlled easily with chemical control methods. Once broad-leaved weeds are controlled then forb species can be planted into the bunchgrass matrix.

Just as Scotch broom control requires a long-term vision and program, the planting of oaks is a long-term effort. While the survivorship and growth of the transplanted oaks is encouraging, it must be remembered that there is an extremely long period between the transplantation of an oak seedling and its growth into a productive habitat tree. On-going maintenance of the young trees should be minimal. Once established the trees should not require watering or fertilization except during the most extreme conditions. But the trees do need to be protected from severe disturbances, such as being driven over by vehicles or cut by mowing equipment. If undisturbed and with good growth these seedlings should produce a viable habitat tree within a decade or two.

Development of Restoration Goals

Oregon white oak habitats are critical components of the regional biodiversity of McChord AFB and 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. Unfortunately, much of the oak habitats have been eliminated or degraded. Since European settlement, over half of all oak habitat has been eliminated.

Degradation of oak woodlands continues today with many areas missing key ecological processes especially frequent and regular fire and oak regeneration. Individual stands 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. The invasion of non-native species can also degrade oak woodlands, with Scotch broom a serious threat throughout McChord AFB. Finally, many oak habitats are degraded by human uses, including military training.

Development of restoration goals for oak woodlands required work along two aspects. First a framework for discussion and analysis needed to be developed. This framework gives a conceptual baseline for initial discussions and detailed analysis. The second aspect needed was additional biological information concerning two critical resource groups, birds and butterflies. Studies of these two groups were therefore completed to fill data gaps necessary to develop adequate restoration goals. Each of these three projects is discussed further below. It should be noted that only portions of each project were funded through this study authorization.

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

Our methodology for the development of restoration goals for Oregon white oak woodlands 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. Through this methodology seven oak habitat types, both historic and contemporary, and then referenced priority species or groups against habitat types that would satisfy those species' requirements. This yields an analytical model that facilitates the development of restoration goals.

Two major points are evident from the analysis. 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 a larger landscape is needed to conserve the entire suite of biodiversity goals. Second, even within habitat types, the specific habitat requirements of priority species may require special restoration goals.

The full text of this analysis was submitted previously to McChord AFB and is again included in Appendix 1.

Critical Habitat Components for Four Rare South Puget Sound Butterflies

The Nature Conservancy and Washington Department of Fish and Wildlife collected information on the life history requirements of four rare south Puget Sound

Fig. 6 Mardon skipper, one of the four butterfly species studied.

butterflies in 1998-1999; the mardon skipper (*Polites mardon*) (Fig. 6), Puget blue (*Plebejus icarioides blackmorei*), Whulge checkerspot (*Euphydryas editha taylori*) (Fig. 7) and valley silverspot (*Speyeria zerene bremnerii*). Our study focused on adult feeding behavior and habitat selection. We also documented plant species used for egg-laying and larval food for three of the butterflies studied. Our goal was to provide critical information regarding the relationships of these rare butterflies with grassland plants and micro-habitats in order to enhance on-going prairie restoration efforts. We followed individual butterflies to count and identify nectar plants, comparing plants used with those available. We also collected information on the distribution and density of principal nectar species, habitat composition and height and cover of Scotch broom.

For each butterfly species studied in 1998, one particular plant species dominated the nectar observations. For the mardon skipper, this was the early blue violet, for the Puget blue it was the sickle-keeled lupine and for the valley silverspot, it was Canada thistle. In 1999, significant changes in nectar preference occurred for the mardon skipper (selection of the non-native, common vetch) and valley silverspot (selection of showy fleabane).

Results of this study suggest that these grassland butterflies generally select areas with relatively low Scotch broom cover. The presence of abundant and diverse nectar plants appears to be an important habitat feature. Results also indicate that, except for possibly the Puget blue, butterfly emergence and plant phenology are not similarly timed during spring and summer. This resulted in different plant species providing critical nectar in different years. The mardon skipper and Whulge checkerspot made considerable use of edge habitats and used a variety of habitat types, including wet meadows and grasslands shaded by oak and Douglas-fir trees. These habitats were likely selected with varying weather conditions and nectar plant phenology.

Fig. 7 Whulge checkerspot, one of the four butterfly species studied.

We recommend that south Puget Sound grassland management and restoration efforts emphasize maintaining and restoring areas with abundant nectar species, especially along forest or tree/grassland edges. Maintaining nectar and larval foodplant species, as well as access to these vital resources, may in many instances require control of tall, non-native grasses. Continued control of Scotch broom is essential for grassland butterflies. We recommend (as other authors have) that management activities such as planting, burning, mowing, hand control of invasives, and herbicide spraying be conducted: a) with knowledge of rare butterfly locations and habitat use, and b) at a scale that will not adversely affect rare butterfly populations.

Our observations suggest that late-season nectar sources may be limiting for many butterfly species. In degraded habitats, like those remaining on south Puget Sound grasslands, non-native species including Canada thistle can fill important ecological niches. Although considered a noxious weed, we do not recommend eradication of this species. Further studies of late-season

nectar sources should be initiated with the intent of identifying native nectar plants for augmentation in restoration.

The full report on butterfly habitat requirements is attached as Appendix 2.

The Status and Micro-Habitat Selection of Streaked Horned Lark, Western Bluebird, Oregon Vesper Sparrow and Western Meadowlark in Western Washington

The grasslands of south Puget Sound are among the most endangered habitat types in Washington State. Four bird species of management concern, the Streaked Horned Lark, Western Bluebird, Oregon Vesper Sparrow (Fig. 8) and Western Meadowlark were chosen as study subjects.

Part 1 of the attached report is a status review to see if any of these species qualify for protection under the Endangered Species Act of Washington Administrative Code for threatened and endangered species. For each species, the current legal status, taxonomic status, life history, historical distribution, current distribution, reasons for decline, future outlook and research needs are discussed. The status review of the Streaked Horned Lark also includes the results from 1999 surveys to better determine its current range in western Washington.

Fig. 8 Vesper sparrow, one of four bird species studied.

To qualify for protection an organism must be a valid taxonomic or evolutionary significant unit and have experienced a significant decline over the majority of its range. Western Bluebird and Western Meadowlark would not qualify for listing under these criteria. The Streaked Horned Lark and Oregon Vesper Sparrow do qualify for protection.

Part 2 of the report is the results of a study to determine the foraging microhabitat requirements of these birds in the remaining high quality prairies of the south Puget Sound. Three primary variables were measured; vegetation height, vertical density and horizontal density. The foraging microhabitat and prairies sites were compared with grasslands that are under active restoration. The grasslands under restoration are significantly different than those found in prairies and foraging sites. The foraging sites for Streaked Horned Lark and Oregon Vesper Sparrow are significantly different than random sites in the prairies. These birds, the Streaked Horned Lark and Oregon Vesper Sparrow, are highly threatened bird species and are in urgent need of conservation.

The entire report on bird habitat requirements is attached as Appendix 3.

Development of Restoration Techniques

Oak Woodland Understory Restoration: Site Preparation and Plant Establishment Methods

Background

Establishing native species in the understory of oak woodlands and associated prairie areas is essential for a complete and effective restoration. This is especially true in locations where the understory has been degraded to such an extent that few native plant species exist in the understory. Many animals, including rare butterflies and birds, require restored understory for their habitats. Techniques to efficiently accomplish this type of restoration are critical to continued success in enhancing the natural resources of McChord Air Force Base.

Previous restorations in the South Puget Sound region utilized a variety of restoration techniques, including post-planting care and planting techniques. But little attention has been placed on pretreatment of areas prior to planting. This experiment examines three pretreatment techniques along with two different planting techniques. The pretreatment techniques focus on controlling non-native plants and their seed. The techniques are solarization, tilling and tilling combined with herbicide control. Planting techniques include the normally utilized planting of plugs and direct seeding of a variety of native grasses and forbs.

Methods

The experiment was initiated in the spring of 1998 in the Bensten Wetland area, a proposed Research Natural Area on McChord Air Force Base. A location of disturbed grassland just north of a historic homestead (Fig. 9). This site was recently supplemented with transplanted oak trees and is typical of much of the area in the South Approach Zone of McChord Air Force Base. It contains few remnants of the native understory and is suitable for destructive pretreatment techniques.

Each of the three site preparation techniques was replicated in five 10 x 10 m plots for a total of fifteen experimental plots. The preparation techniques included tilling in both the spring and fall, spring tilling and fall herbicide application and solarization. The fall herbicide application consisted of a 2% solution of glyphosate (Roundup) applied via a backpack sprayer. Solarization was accomplished by placing black plastic over the plots and keeping it in place throughout the summer, until the fall planting.

Within each plot, two-thirds was plugged with native grass and forb seedlings in October and November of 1998. The empty third of the plot and the adjacent third containing plugs was also

direct seeded in November. Approximately 10,000 seed of each of 14 species (Table 4) were used.

In addition, to the fifteen experimental plots an additional double plowed plot was established to follow the survival and growth of spring vs. fall transplanted plugs and direct seeding. Within this plot 25 plugs of each of the plugged species were planted and 100 seeds of each species sown. Survivorship, growth and germination will be measured in the spring of 1999. These efforts should yield a more controlled picture of growth and mortality of plantings and seeding.

Monitoring of the experiment occurred in June 1999 and 2000. The growth of individuals was measured, especially concentrating on Idaho fescue, the main component of the understory. Three characteristics growth and production of Idaho fescue were measured, plant height, width and the number of inflorescence produced.

The overall quality of the native understory was also examined by measuring the percent cover for Idaho fescue and native and non-native species groups, i.e. graminoids other than fescue, forbs and woody species. These prairie quality measurements give a good indication of the usefulness of prairie habitat and have been used for large-scale monitoring of prairies in the South Puget Sound.

Table 4. Native plant species plugged and direct seeded near Bensten Wetland, McChord Airbase, October-November, 1998.

Species	Plugged	Seeded
Grasses		
California oatgrass	X	X
Idaho fescue	X	X
Forbs		
Bluebells		X
Common camus		X
Cutleaf microseris	X	X
Oregon sunshine	X	X
Pomocelery lomatium	X	X
Prairie lupine		X
Puget balsamroot		X
Showy fleabane	X	X
Slender cinquefoil		X
Spikelike goldenrod	X	X
Western buttercup		X
White-topped aster		X

Results

The pretreatment of the sites yielded visually similar results, with the majority of pest plants controlled initially, though in the second year non-native plants increased their cover. Numerous non-native annual plants continue to germinate in the plots and contribute to high percent cover of non-native forbs. Survivorship and growth of Idaho fescue plugs was quite good in all locations. Nearly all the planted plugs of Idaho fescue survived, with no statistically significant difference between pretreatment types or planting regimes. The mean survivorship was 97.6%. In addition, most individuals of Idaho fescue grew tremendously during from fall through spring, with the average fescue plug tripling in size the first year and then tripling again during the second year.

Although qualitatively all of the pretreatments were effective, the tilling and solarization plots exhibited better growth and production of Idaho fescue. The width of Idaho fescue transplants has been the best measure of plant vigor in past experiments. In this experiment it did not vary significantly between pretreatments, with the widest plants occurring in the herbicide plots, followed by the tilled and solarization plots (Fig. 10).

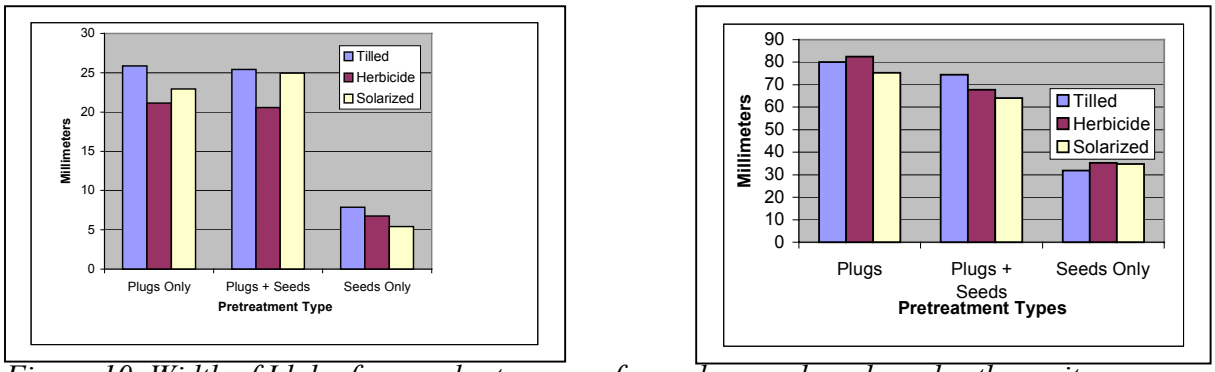

Figure 10. Width of Idaho fescue plants grown from plugs and seeds under three site pretreatment types after one year (left) and two years (right).

Other measurements of Idaho fescue growth and production, plant height and the number of flowering inflorescence also showed little difference. The plants in the herbicide treatment were taller than those in the other treatments, while these same plants had fewer numbers of inflorescence that either the tilled or solarized treatments (Table 5 & 6).

Table 5. Maximum height of plugged and seeded Idaho fescue within three pretreatment types, during the first and second year.

	Plugs Only	Plugs + Seeds	Seeds Only
Tilled	20.56 / 31.1	20.88 / 30.9	8.12 / 25.5
Herbicide	18.4 / 35.1	16.64 / 36.1	7.23 / 28.0
Solarized	18.36 / 32.9	19.72 / 33.2	6.40 / 16.4

Table 6. Number of inflorescence of Idaho fescue within three pretreatment types during the first and second year. Plants in the herbicide plots produced significantly fewer inflorescence.

	Plugs Only	Plugs + Seeds	Seeds Only
Tilled	1.88 / 85.5	4.28 / 65.5	0 / 1.1
Herbicide	0.16 / 59.8	0.36 / 53.8	0 / 2.9
Solarized	2.2 / 82.8	3.64 / 59.1	0 / 0.8

The Idaho fescue from plugs was significantly bigger and more robust than the direct seeded individuals after both one and two years. This was true for all measurements and with all pretreatments. Interestingly, few of the seeded fescue obtained large enough size or plant reserves to flower after even the second growing season, while just over a third (39.3%) of the plugged individuals produced flowers the first year and nearly all (99.8%) produced flowers the second.

The prairie quality measurements showed fewer differences than the growth data. During the first year the cover of fescue was significantly ($p<0.05$) greater, by almost 50% greater, in the tilled plots than in either the herbicide or solarized plots (Fig. 11). But this trend did not continue into the second year when all three treatment types had similar cover of fescue (Fig 11.) The positive effects of seeding were more apparent after the second year, when the plots with both plugs and seeds had significantly higher fescue cover.

Unfortunately, the relatively good results concerning the cover of non-native plants obtained during the first year did not continue into the second. Cover of both invasive forbs and grasses was high after the second year. In addition, this trend was similar for all three treatment types, no treatment was especially effective in precluding the non-native species. The dramatic increase in non-native species likely occurred from germination from the seed bank in the fall and possibly seed rain from nearby vegetation.

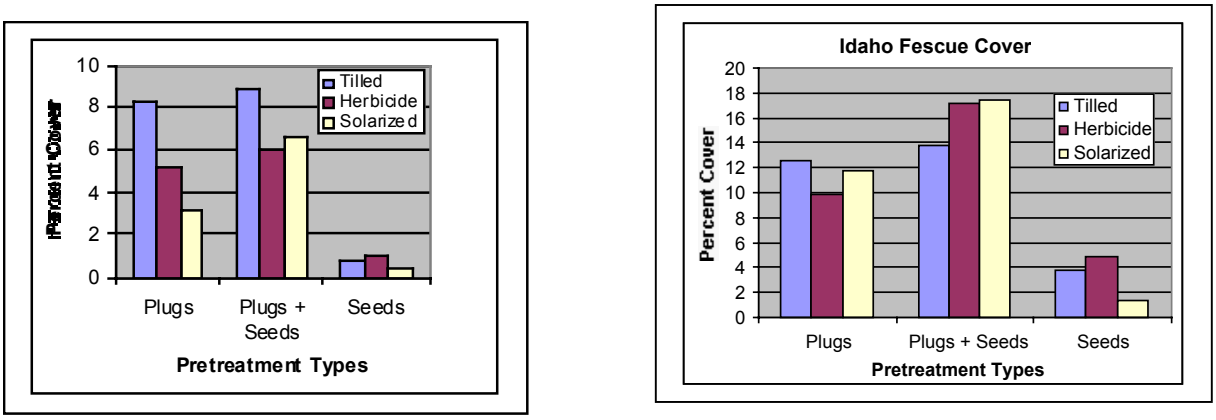

Figure 11. Percent cover of Idaho fescue plants grown from plugs and seed under three site pretreatment types after one year (left) and two years (right)..

The plants and seeds planted within the plot designed to better track survivorship and growth of different species performed similarly to those in the larger experiment. The survivorship of plugged plants was high (Table 7), though predation, most likely from deer, caused some mortality. Growth of these plants was generally vigorous, though again predation set some individuals back. Flower production did occur in this first year for several species including, Idaho fescue, Oregon sunshine, cutleaf microseris and California oatgrass. Survivorship and germination patterns maintained themselves during the second year

Unfortunately, germination of seed was limited. In fact only a single species, *Lupinus albicaulis*, germinated within this plot (Table 7). Nine individuals of this species germinated. Further germination did not occur during the second year.

Summary

The establishment of understory vegetation in the South Approach Zone of McChord Air Force Base has shown initial and on-going success. This especially true for the areas established with plant plugs. High survivorship, from 75 to 100%, and rapid growth was exhibited by all species within each of the three pretreatment types. These plugged areas are well on their way towards high quality prairie and oak woodland understory.

Table 7. First year survivorship and germination rates for species planted within the sixteenth plot.

Species	% Survival Plugged	% Germinated Seeded
Grasses		
California oatgrass	95	0
Idaho fescue	85	0
Forbs		

Bluebells		0
Common camus		0
Cutleaf microseris	100	0
Oregon sunshine	85	0
Pomocelery lomatium	75	0
Prairie lupine		9
Puget balsamroot		0
Showy fleabane	100	0
Slender cinquefoil		0
Spikelike goldenrod	80	0
Western buttercup		0
White-topped aster		0

Each of the three pretreatment types was marginally successful. Woody non-native species and pest pasture grasses were controlled with all three pretreatment methods during the first year. Spring germination of non-native forbs and grasses was prevalent and contributed to high coverage by non-native forbs and grasses after two years.

Overall, the double tilling was the most successful, with slightly larger plants and easier logistics. Tilling is the current recommendation for the preferred method for future restorations within severely degraded areas.

Additional Actions

Control of Knapweed

Background

Knapweeds are some of the most perilous rangeland weeds in North America. They infest an area estimated to cover more than 2 million hectares in the western United States, and the area of infestation is increasing at an estimate 18 percent per year. Knapweeds (Fig. 12) are highly competitive and aggressive plants that form dense colonies, eliminating native grassland species. Knapweeds are especially adept at spreading along rights-of-way and farm roads. Disturbed or overgrazed lands are prime candidates for colonization, though these plants can also invade undisturbed grasslands.

Fig. 12. The bright flowers of spotted knapweed (and the other knapweeds) are easily seen and identified.

Knapweeds typically suppress other vegetation by intense competition for limited soil water. Knapweeds can also produce allelopathic chemicals, which suppress the growth of other species, allowing the knapweed to grow in single-species stands. These are serious weeds that can drastically alter the composition and productivity of natural and production lands in western Washington.

The immediate control and eradication of knapweed on McChord AFB is of the highest priority.

Two different species of knapweed have been identified from McChord AFB. These species are diffuse and spotted knapweeds. Each of these knapweeds has slightly different ecological and biological characteristics, though control techniques are similar for both species. Summaries of the biology, impacts and control methods for the three species are included as Appendix IV.

Actions

The discovery of a patch of knapweed on McChord AFB in 1997 was extremely disturbing. This discovery was communicated to base personnel and the control of the patch initiated by McChord AFB personnel. Subsequently, additional patches of knapweed have been found on and adjacent to McChord AFB. Now, knapweed has been located on McChord AFB in more than a dozen locations (Fig. 13). It should be stressed that these discoveries have occurred only as a consequence of our other work on McChord AFB and they do not represent a comprehensive survey. Therefore, we believe additional patches of knapweed currently occur on McChord AFB.

The Nature Conservancy also implemented control efforts on several patches of knapweed in 1998 – 2000. In 1999 and 1999 we concentrated on those patches that lie in between Ft. Lewis and McChord AFB since these populations did not get controlled by either military entity. In 2000, we also controlled patches along Perimeter Road, where plants were going towards seeding without being controlled. More than 1,250 individuals of knapweed were controlled in this area during 2000 (Fig 14).

All control efforts consisted of manual pulling of mature plants prior to seed set. All plants were placed in plastic bags and disposed in the local landfill.

Discussion

The seemingly escalating level of infestation of knapweed on McChord AFB suggests that previous control efforts have been insufficient to control these weeds, let alone eradicate them. Eradication should be the goal for the knapweeds. They are relatively new invaders and their

distributions are still limited. Failure to control this threat will eventually result in negative impacts to the prairie landscape throughout the South Puget Sound Region.

Since the knapweed has spread beyond the borders of McChord AFB, an effective eradication program will require partnering with outside agencies and adjacent landowners. A cooperative program between McChord AFB, The Nature Conservancy, Pierce County Weed Board, Ft. Lewis and local landowners should be a powerful force. Such a partnership could develop a comprehensive plan that includes systematic searches, effective control efforts, rigorous monitoring and public information. Implementation of such a plan could alleviate the problem in a matter of a few years.

The development and implementation of an eradication program for knapweeds on and around McChord AFB should be one of the highest priorities for the environmental division.

Recommended Future Actions

Tremendous strides towards restoring and enhancing the oak woodlands of McChord AFB have been completed during this project, yet additional actions are needed to maintain the advances and to successfully conserve the resources of McChord AFB. Several future actions are recommended; these include:

- collaboration with regional conservation efforts,
- implementation of a knapweed eradication program;
- continuation of a persistent, effective Scotch broom control program,
- expansion of restoration efforts on McChord AFB.

Each of these components expand on the work completed during this project and help McChord AFB reach their goal of conserving the unique natural resources on the base within the context of an active military base.

Regional Cooperation

Many of the priority resources on McChord AFB extend onto Ft. Lewis and other adjacent lands. In addition, many of the animals that do occur on McChord are also reliant on habitats outside the boundaries of the base. This combination of factors emphasizes the need for McChord AFB to work with other conservation partners throughout the South Puget Sound region. Such collaboration will help insure that viable populations of conservation targets are maintained off of military lands, decreasing the reliance of these species on McChord AFB. This strategy is especially important as the US Fish and Wildlife Service is now considering several species in the region for listing as threatened or endangered species. The development of an effective partnership now may help to preclude some of the seemingly imminent listings.

A group of government agencies and non-profit organizations, including The Nature Conservancy of Washington, has begun to build such partnerships in the South Puget Sound region. Participation of McChord AFB in this group will be a significant benefit to both McChord AFB and the region as a whole. This partnership will help target conservation actions and the resources available. It should also increase the likelihood that some outside sources of funding for restoration and management work can be obtained. Participation in such a partnership should be a win-win situation for all parties.

Knapweed Eradication Program

The importance of developing and implementing a knapweed eradication program can not be understated. These weeds are the greatest new biological threat to prairies and oak woodlands in the last twenty years. Eradication of a new invader is substantially easier when the populations are small and limited in distribution. The knapweed on McChord AFB is just at the brink of expanding dramatically. If eradication is to be possible without huge amounts of time and resources, a program needs to developed and implemented prior to the growing season of 2001.

Optimally, this program should collaborate with Ft. Lewis, where knapweed also has a foothold, and the Pierce County Weed Board. These two entities, combined with McChord AFB, should have the resources and access to properties to complete such an eradication program. The program needs to include a comprehensive survey and monitoring program along with a treatment program. The survey is needed since an effective treatment program needs to affect all patches of knapweed, not just the currently know patches. Monitoring is needed to document success and to help ensure that any patches that were not completely treated the first time are caught before they produce seed.

Continued Broom Control

Scotch broom continues to be the single largest biological threat to the ecological integrity of natural habitats on McChord AFB. The control of Scotch broom has been a significant portion of this project and it needs to continue to be a significant portion of on-going restoration and management on McChord AFB. Controlling Scotch broom is a long-term effort due to the longevity of a soil seed bank. The key to success is consistent control efforts that limit production of new seed and kill existing plants.

The techniques for controlling Scotch broom are well known and have been discussed in this report. The wise implementation of these techniques will result in areas where Scotch broom is controlled and does not interfere with the necessary ecological processes. One additional benefit is that the amount and intensity of control efforts should decline with time. Hopefully, ten years from now Scotch broom control in the natural areas of McChord AFB will only involve searching for isolated patches of plants and controlling these patches.

Expansion of Restoration Efforts

Much of the restoration efforts for this project have focussed on a small set of oak woodlands. This strategy was utilized since many of the efforts were experimental and not ready to implement on larger scales. Expansion of restoration efforts into larger areas will have several benefits. The greatest benefit may come from the integration of Scotch broom control and restoration efforts. Restoration of native understory vegetation as part of Scotch broom control will help increase the effectiveness of the control efforts and also speed the conversion of the land back to being productive. Several possible techniques could be used complementarily though seed drilling Idaho fescue seed into areas devoid of native grasses is the most obvious.

Other target actions would include the expansion of the native understory areas surrounding Bensten Wetland. These areas need to reach a critical size to meet their ecological goals. Other areas, which should be considered for additional restoration actions, are major portions of the South Approach Zone and the Porter Hills. Both of these areas have been suggested previously for nomination as Research Natural Areas.