Jeff Foster
Forestry Branch
I Corps & Ft. Lewis
ATTN: AFZH-DEQ
Fort Lewis, Washington 98433-5000

WESTSIDE STORY: RESTORATION OF A PONDEROSA PINE FOREST AT FORT LEWIS ARMY BASE

Jeffrey R. Foster

Abstract

Fort Lewis, Washington, a U.S. Army installation between Tacoma and Olympia, has the largest natural population of ponderosa pine west of the Cascade Range. Historically, the area was maintained as open pine forest or pine savanna by frequent surface fires set in the adjacent prairies by Native Americans. The understory was native prairie grasses (especially Idaho fescue), sedges, and forbs. With the arrival of Europeans, fire frequency declined, but the pine forest remained relatively intact until World War II. Since that time, two major changes have occurred. First, most of the original, open-canopy pine forest has been converted to closed-canopy, Douglas-fir forest with remnant overstory pines. The dense shade under this canopy has eliminated pine regeneration and the original prairie ground cover. Second, the pine population has expanded southwards onto the largest prairie on Fort Lewis, creating a "colonization" forest. In portions of this new forest, thickets of young Douglas-fir are now crowding the pines and shading out prairie plants. Other portions are being invaded by Scotch broom and colonial bentgrass, reducing cover of native prairie species. Ten years of prescribed burning in yet another portion have stopped encroachment by Douglas-fir and Scotch broom, but have not prevented a decline of the native prairie flora.

Restoration of the pine forest is slated for approximately 1,100 acres. The goals of this effort are : 1) a combination of open, pine-fir forest and pine savanna across the area; 2) maintenance of existing native prairie understory and, where feasible, restoration of prairie understory where it has been lost; 3) a self-perpetuating, all-aged population of pine; and 4) reintroduction of fire as an important ecological process. To prepare the area for fire, a combination of management actions is being undertaken: (1) slashing pre-commercial-size Douglas-fir; (2) removing commercial-size Douglas-fir in timber sales; (3) cutting the densest concentrations of Scotch broom, and thin out pine saplings. Subsequently, a 3 – to 5-year cycle of prescribed fires will help keep Scotch broom in check, create a suitable seedbed for pine reproduction, and hopefully, prevent further loss of native prairie species. Prospects are uncertain for restoration of prairie understory where it has been completely eliminated.

Because the area is used for military training, this project faces unique challenges and tradeoffs. For example, opening up the forest could result in increased military vehicle movement, which would preclude restoration of prairie understory in some areas. In addition, nearly half of the project area is used for firing ranges, and is normally closed to civilians. Restoration will be permitted in this area to reduce the high summer fire hazard, which often restricts the use of the

ranges or closes them down entirely. However, due to the limited access, restoration activities there may take many years to complete.

INTRODUCTION

Ponderosa pine forests occur in semiarid regions throughout western North America, and are a widespread and familiar plant community on the east slopes of the Cascade Range. Most residents of western Washington and Oregon would be surprised to learn that this species also occurs naturally west of the Cascades, as scattered populations in the Puget Sound Lowlands and the Willamette Valley.

The largest of these populations is located on Fort Lewis, Washington, a 39,000-hectare (ha) U.S. Army base. Here, ponderosa pine occurs across 775 ha (Figure 1). Since European settlement in the mid-1800's, dramatic ecological changes have occurred in Fort Lewis' varied ecosystems. As a result, the unique pine forest bears little resemblance to its original condition.

In the past few years, Fort Lewis has embarked on an ambitious program of ecological restoration, including prairies, oak woodlands, and the pine forest. This paper describes the current ecological condition of the pine forest, my "best guesses" as to its pre-European ecological condition, and the goals and methods of the restoration effort.

THE FORT LEWIS PINE FOREST

Location

The core of the pine forest is a 500-ha area centered on the junction of the Eastgate Road and the Burlington-Northern Railway, in the middle of the northern (Pierce County) portion of Fort Lewis (Figures 1 and 2). This will be referred to hereafter as the "Eastgate/B-N forest." The largest prairie on Fort Lewis, 91st Division, lies immediately to the southwest. There are also several outlying pine stands, and scattered pines on other prairies and in nearby, Douglas-fir-dominated forests.

Climate and Soils

The climate is humid maritime, with cool, rainy winters and warm, dry summers. Average annual precipitation is 84 centimeters (cm), with 70 percent of annual rainfall occurring between mid-October and February. Summer drought is typical; average July/August rainfall is only 2.5 cm. Mean monthly temperature ranges from 2.5 degrees Celsius (^{o}C) in January to 18.3 ^{o}C in July. Subfreezing temperatures are uncommon during the winter, and snow rarely falls.

The Fort Lewis pine forests grow on flat terrain on the Spanaway gravelly sandy loam soil series (Anderson and Ness 1955). This soil formed on glacial outwash under prairie or savanna vegetation. The surface horizon is very stony (average 50% rock), and is underlain by gravel and cobbles. As a result, this soil is extremely well-drained, and has lower summer soil moisture than other, less well-drained soils in the region.

Holocene History

Ponderosa pine became established in the Fort Lewis area between 10,000 and 6,000 years ago, a warmer, drier period than today (Barnosky 1985, Brubaker 1991). At that time, ponderosa pine may have grown in a continuous belt from Vancouver, B.C., to

Eugene, Oregon. Then, as the climate became cooler and wetter, its range contracted until only isolated, remnant pine populations remained on the Westside (Brad St. Clair, U.S. Forest Service, personal communi-cation).

The pines grew on or at the edges of the prairies, which were maintained to the present day by frequent surface fires set by Native Americans (Van Perdue, Fort Lewis, personal communication). These fires probably burned into the pine stands, reducing surface fuels, limiting the establishment of Douglas-fir, and thinning out small pines. The result may have been a combination of pine savanna and open pine forest with scattered Douglas-fir and Oregon white oak. The understory was likely native prairie dominated by Idaho fescue.

The first settlement in the Fort Lewis area was Fort Nisqually, established in present-day Dupont in 1833. Grazing and farming followed, and by the late 1800's many homesteads dotted the area. In the Eastgate/B-N area, "red pines" were noted as occurring in 1852 (Tilton 1855). Land survey records from 1870 indicate that most of the base was prairie, and ponderosa pine was present on as much as 3,200 ha (Tilton 1855, Public Forestry Foundation 1996). Since 1870, forests dominated by Douglas-fir have replaced approximately 5,000 ha of the original prairies (Public Forestry Foundation 1996).

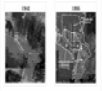
Aerial photographs from 1942 show that the boundaries of the Eastgate/B-N forest were similar to those of 1870 (Figure 2). Since 1942, however,the forest has become denser, and the pine population has expanded south onto the east end of 91st Division Prairie, an area where, in 1942, pines and Douglas-fir were very widely scattered (Figure 2).

Logging along the lower Nisqually River began around 1890. By the time Fort Lewis became a military reservation in 1917, most of the forests had been cut down. Renewed clearcutting by the Army occurred between 1934 and 1952. As a result, 90 percent of the installation's forests were less than 70 years old in 1964 (Public Forestry Foundation 1996). The Eastgate/B-N forest appears to have been spared until 1968, when a small timber sale removed mature pines from approximately 12 ha in its northeast corner. Douglas-fir was thinned in the same area in 1992. In 1985, most of the mature Douglas-firs were cut from 120 ha in the southeast portion of the Eastgate/B-N forest. This area has simce been prescribed burned four times, most recently in winter 1996, as part of an "unofficial" pine restoration project.

Current Ecological Condition

The modern forest structure in the Eastgate/B-N area falls into two categories. The first category is 180 hectares of "original" forest, i.e., occupying the same location where forest cover was present in 1870. This forest consists of a dense overstory dominated by Douglas-fir, with scattered mature pines. Some of the pines are over 200 years old (Dave Rolph, The Nature Conservancy, personal communication). Tree regeneration is sparse, and the original prairie ground cover has been completely replaced by forest understory species. Under the densest stands, moss dominates the forest floor. In the area where mature pines were logged in 1968, there is now a mixture of even-aged Douglas-fir and all-aged pine stands. All of the Douglas-fir were cut in 1992 from about 5 ha along the Burlington-Northern right-of-way, leaving widely spaced, mature pines.

The second category is "colonization" forest, occupying about 320 ha to the south of the original forest. Stand structure is extremely heterogeneous across this area. One block of about 10 ha is occupied by an all-aged forest of pine with a relatively intact, native prairie understory. Approximately 15 ha are dominated by dense stands of young Douglas-fir and roughly 20 ha are pine/Douglas-fir savanna with widely scattered, mature trees. In the 120-ha block where unofficial restoration has occurred, there is an open, all-aged pine forest.



The cumulative effects of military training have been substantial. Construction of roads and firing ranges has permanently eliminated about 115 ha of natural vegetation in the Eastgate/ B-N area. Ground cover has been

heavily disturbed by vehicle movement, especially tracked vehicles such as tanks, and to a lesser extent by trenches dug by troops. Training directly damages prairie vegetation and tree seedlings, and creates bare soil where exotic species can become established.

Active fire suppression since World War II has had both negative and positive consequences for the pine population. The large increases in Douglas-fir and Scotch broom were made possible by the absence of fire. Yet, the lack of fire also allowed the pine forest to increase in total acreage as pines colonized 91st Division Prairie.

Limited quantitative stand structure data area now available for the colonization forest, based on permanent plots laid out in summer 1996. Twelve of these plots are in

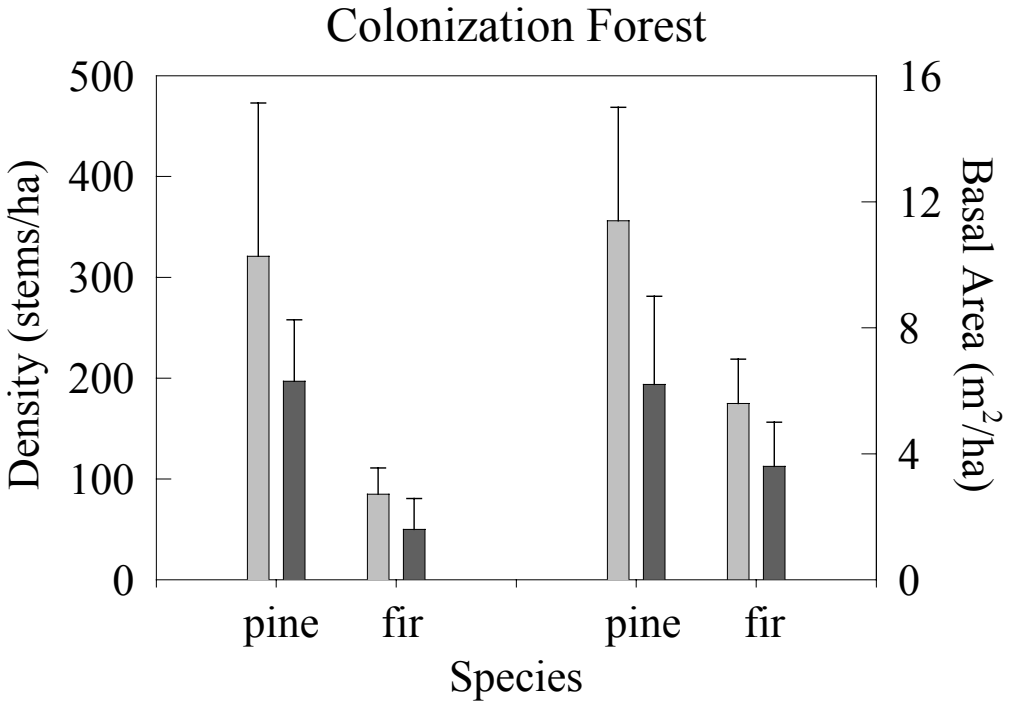
Where the colonization forest canopy is sufficiently open (less than 50% canopy cover), Scotch broom is often present, sometimes forming dense brushfields. Under some stands, the prairie understory is entirely gone, while under others it still persists. Even where prairie understory is present and free of Scotch broom, there is a significant presence of other exotic species, especially colonial bentgrass and hairy catsear.

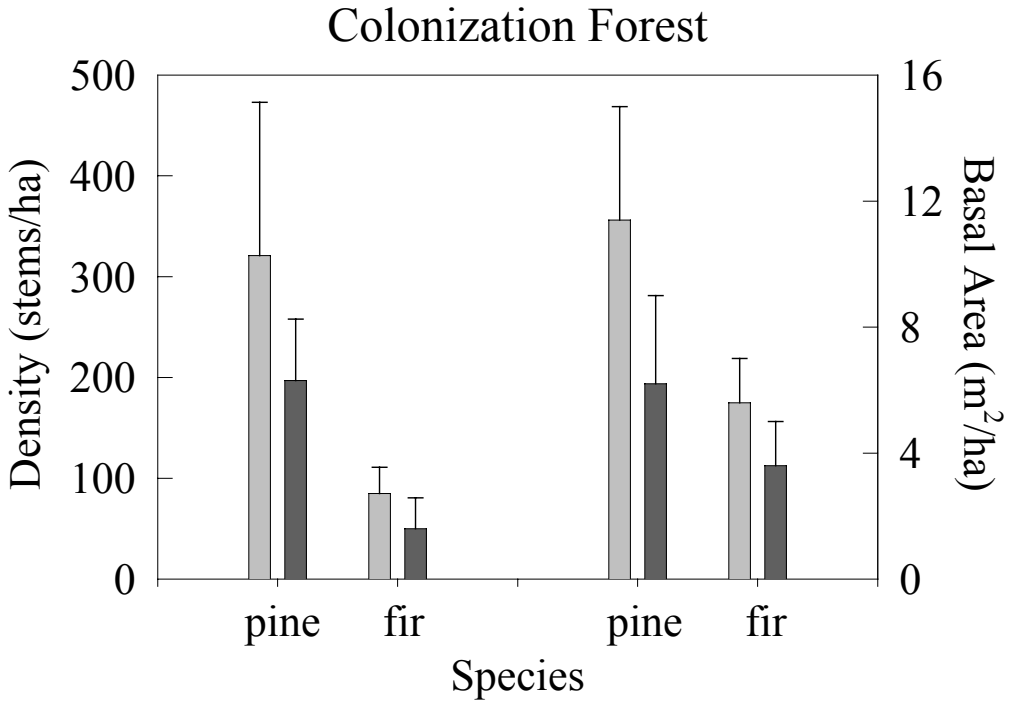
areas recently (1994-1996) burned (prescribed fires or wildfires), and seven plots are in areas never burned or last burned decades ago. Plots have not yet been laid out in the original forest because most of it is in a "small arms impact area" where access is severely restricted.

Each randomly located plot uses a systematic arrangement of subplots of varying size for stratified sampling of overstory trees (≥ 25 cm diameter at breast height [DBH]), subcanopy trees (5–24.9 cm DBH), tree regeneration (saplings and seedlings), shrubs, and ground cover. Increment cores are removed at breast height from systematically selected overstory trees for age determination from xylem ring counts. Overstory and subcanopy pines are surveyed for presence of cones. Coarse woody debris (snags and logs) and tree growth rates are also measured.

Because the colonization forest is so heterogeneous, forest structure varies widely among plots (e.g., the large standard errors in Figure 3). Both pine and Douglas-fir in burned areas have significantly lower tree

density than in unburned areas, but basal area does not differ between burned and unburned areas (analysis of variance, significance level = 0.05) (Figure 3). A comparison of diameter distributions in burned and unburned areas suggests that the primary effect of recent fires has been to kill small-diameter trees of both species (Figure 4). The loss of these small trees had a disproportionate impact on density compared to basal area

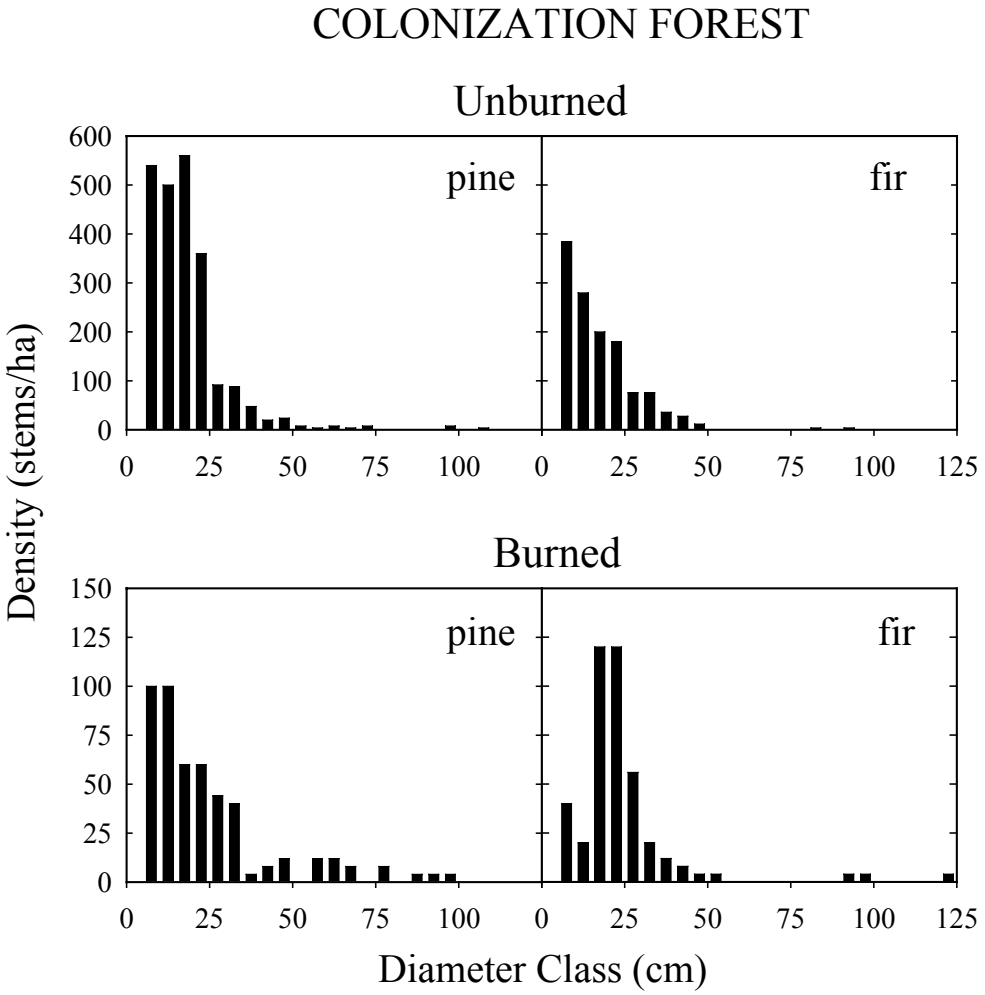


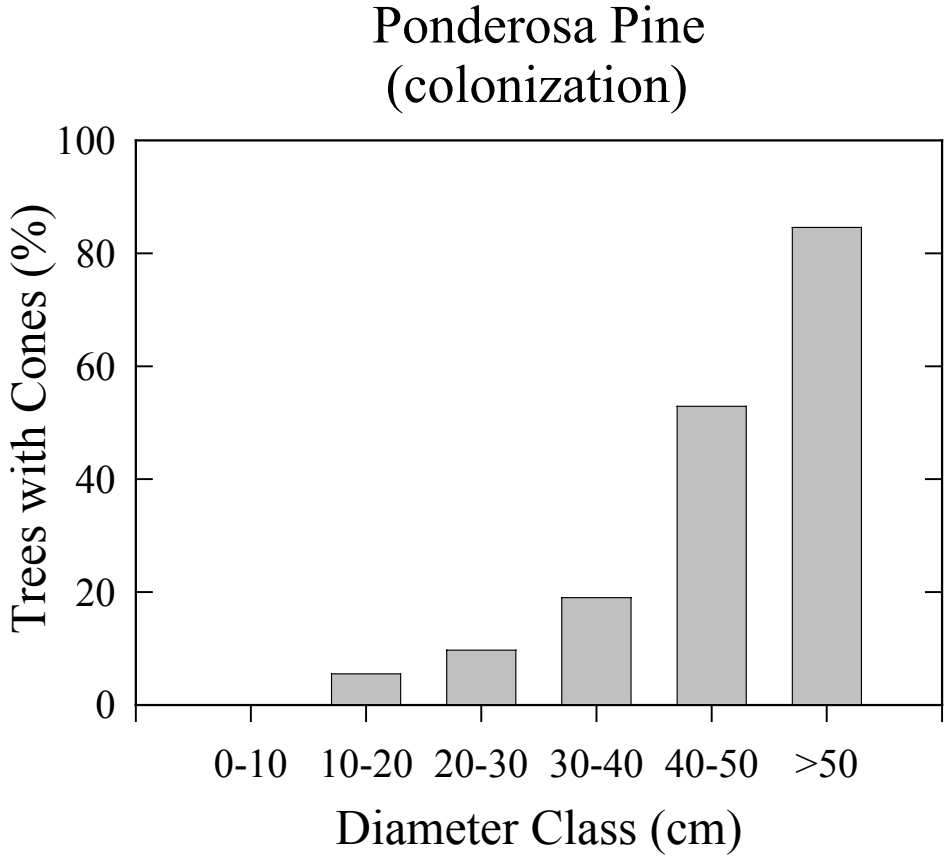


The J-shaped diameter distributions of pine in both burned and unburned areas suggest that this species' population is self-replacing (Figure 4). However, no pine seedlings occur in any of the permanent plots. In fact, pine seedlings are hard to find anywhere in the Eastgate/B-N forest, so in recent years there has been no pine establishment. Part of the explanation may be a paucity of seed. Not until pines reach 50 cm DBH are they highly likely to bear cones (Figure 5). Pines this large are uncommon (Figure 4), and examination of cone-bearing trees in summer 1996 revealed a high incidence of cone abortion and a low rate of seed filling.

The average age of overstory pines in the colonization forest is 38 years, with a range of 19 to 111 years. These figures include scattered large pines that were already tree-size in 1942. Although the very largest trees are also the oldest, tree diameters are not a good guide to age; several trees over 70 cm DBH are less than 60 years old.

Ground cover in most plots is dominated by non-native prairie species, including colonial bentgrass, velvetgrass, Kentucky bluegrass, hairy catsear, and St. John's wort. On plots with overstories dominated by Douglas-fir, ground cover is mostly moss. Only three plots, all in an unburned area of all-aged pine, are dominated by native prairie species. On these plots, cover of Idaho fescue is as high as 25%, and there is consistent presence of red fescue, long-stoloned sedge, blue camas, brodiaea, chocolate lily, woolly eriophyllum, kinnikinnick, prairie violet, elegant rein orchid, cutleaf microseris, and on two plots, white-topped aster. The area where these plots occur has high light levels (open canopy), low presence of Scotch broom and Douglas-fir, and little military training (no tracked vehicles).


COLONIZATION FOREST
Unburned
pine
fir
Burned
pine
fir
Density (stems/ha)
Diameter Class (cm)
0
100
200
300
400
500
600
25
50
75
125
150



PINE ECOSYSTEM RESTORATION

Objectives

Under my direction, the Forestry Branch at Fort Lewis, in cooperation with The Nature Conservancy and the Integrated Training Area Management program (an Army ecosystem inventory and restoration initiative), has begun restoration of the Eastgate/B-N forest. Our goals are: (1) Restoration to a mixture of pine savanna and open pine/Douglas-fir forest. (2) A self-perpetuating, all-aged population of ponderosa pine. (3) Maintenance of existing native prairie understory, and, where feasible, restoration of prairie understory that has been lost. (4) Reintro-duction of fire as an important ecological process.

How Restoration Goals Were Set

I quickly decided not to restore this area to the conditions that existed before European settlement. This was impractical because of our very imperfect knowledge of what that vegetation was, and because full restoration was not compatible with military training. Instead, my approach was to assume that pre-European conditions were similar to those of much better studied ponderosa forests elsewhere in the western U.S. Then I decided how far towards that condition the forest could be moved in the face of current

ecological trends and the limitations imposed by military training.

Most ponderosa pine forests grow in climates much drier than Fort Lewis. Historical records and retrospective studies of old-growth stands indicate that at the time of settlement, these forests were parklike, with widely spaced pines, few or no shade-tolerant conifers, patchy regeneration, and grassy understories (Cooper 1960, Weaver 1961, McNeil and Zobel 1980, White 1985, Habeck 1990, Covington and Moore 1994). This savanna-like structure was maintained by surface fires, lightning- and Indian-set, with a frequency of 3 to 25 years (Agee 1993, Habeck 1990, Covington and Moore 1994). These fires consumed ground fuels; killed saplings of shade-tolerant Douglas-fir, true fir, and spruce; and created favorable conditions for pine regeneration. The thick bark of pole-size and larger pines allowed them to survive the fires.

Although very tolerant of drought and high temperatures (Harrington and Kelsey 1979, Kolb and Robberecht 1996), ponderosa pine seedlings are shade-intolerant, susceptible to frost, fare poorly in competition with grasses, and have difficulty establishing in the thick duff layers that accumulate under pines in the absence of fire (Belsky and Blumenthal 1995; Steve Stein, Eastern Washington University, personal communication). In addition, good cone crops are infrequent and irregular (Oliver and Ryker 1990). Historically, therefore, decades elapsed between good establishment years with the right combination of seed crop, weather, and fire (White 1985).

European settlement brought large ecological changes to ponderosa pine forests. The commencement of cattle and sheep grazing in the 1880's reduced grass cover, allowing many pine seedlings to become established. In the 20th century, aggressive fire suppression, continued grazing, and high-grading (logging of the largest, most vigorous pines) produced the modern, greatly altered forest structure. Tree densities have increased dramatically, shade-tolerant conifers have invaded pine-dominated stands, thickets of saplings and pole-size trees have created ladder fuels, and surface fuels have accumulated (Cooper 1960, Habeck 1990, Covington and Moore 1994, Belsky and Blumenthal 1995). As a result, when wildfires start, they often enter the canopy and kill mature pines across wide areas. In addition, the canopies cast too much shade for pine seedlings to establish. The ecological changes have been so large and so widespread that some scientists consider ponderosa pine forests to be "unhealthy" throughout the West (Kolb et al. 1994), and the ponderosa pine ecosystem (though not the species) to be endangered in the United States (Noss et al. 1995).

This knowledge of historic ponderosa pine forests told me that our restoration effort would need to, at the very least, reduce overall tree density, reduce or eliminate Douglas-fir trees and saplings, and bring fire back into the ecological picture. It also told me not to expect an immediate surge in pine seedling establishment in the post-restoration forest.

Restoration of the Eastgate/B-N area will benefit both military training and the ecological health of the pine forest. Fort Lewis trainers desire a more open forest that has lower fire hazard and makes movement of troops and vehicles easier. However, training also places limitations on how far restoration can go.

For example, most of the original forest and some of the colonization forest lie within a

small arms impact area containing rifle and grenade ranges. Access to this area is severely limited, but the trainers have given the green light to restoration there because the density of the forest means a high fire hazard, requiring prohibition of tracer bullets during summer droughts. However, the trainers are not in favor of the impact area becoming a savanna.

Outside the impact area, thinning can be more drastic. But as dense stands are opened up, increased maneuvers by troops and vehicles are likely. My greatest concern is tracked vehicles, which are particularly hard on ground cover. Since I wish to preserve as much of the native prairie vegetation as possible, I have decided not to convert all of the area to a savanna. Instead, at least in the first round of restoration, all of the pines, regardless of size, will be retained.

Use of prescribed fire is not a problem. For over a decade, Fort Lewis has conducted prescribed burns for Scotch broom control. Reduction of this pernicious, exotic shrub is highly desirable both from ecological and military training viewpoints.

How Restoration Goals Will Be Achieved

Ponderosa pine forest restoration is occurring at many locations across the western U.S. (Hardy and Arno 1996, Tall Timbers Research Station 1996). I reviewed published literature, personally communicated with persons conducting restoration, and visited a restoration effort on the Boise National Forest, Idaho. From these efforts, I concluded that a mixture of commercial and precommercial thinning, protection of large pines, prescribed fire, and monitoring would be appropriate at Fort Lewis (Table 1).

Table 1. Outline of restoration plan for ponderosa pine forest, Fort Lewis.

COLONIZATION FOREST	ORIGINAL FOREST
Precommercial Work	
cut pole-size Douglas-fir protect large pines	protect large pines
Commercial Work	
cut most large Douglas-fir	cut 50% of canopy Douglas-fir
Prescribed Fire	
every 3 years	every 3-5 years
Monitoring	
establish fixed plots census before/after restoration	establish fixed plots census before/after restoration

The restoration strategy differs between the original and colonization forests. In the colonization forest, all Douglas-firs from 7.6 cm (3 inches) DBH to minimum commercial size (20.3 cm [8 inches] DBH) will be felled and left in place. Firewood cutters will then be allowed in the area to help reduce slash. Subsequently, all commercial-size Douglas-

fir will be removed in a timber sale. Finally, a prescribed burn in the cool, moist conditions of late winter or early spring will further reduce slash and kill Douglas-fir saplings. In the original forest, 50% of the overstory Douglas-fir will be removed in a commercial timber sale, followed by a winter/spring fire to reduce slash.

The largest pines are our most valuable pines because there are not many of them, and because they are the best seed sources (Figure 5). The first prescribed burn in those areas that have not seen fire for many years has the potential to damage the large pines, for two reasons. First, the large pines may be "torched" if saplings growing beneath them form "ladder fuels" into their crowns. Second, large mounds of duff (needles and bark fragments) that have accumulated around the bases of the large pines' trunks may smolder for many days, heating the cambium to lethal temperatures. Therefore, prior to the first prescribed burn in both the original and colonization forests, small trees growing under the large pines' crowns will be cut and the top part of the duff mounds will be raked away. The bottom portions of the mounds will be left in place because the pines grow fine roots into these that may be important in nutrient absorption (Jim Agee, University of Washington, personal communication).

After the initial prescribed burns, Fort Lewis will conduct prescribed fires sufficiently often to keep Scotch broom in check. Based on past experience, a three-year cycle is needed in areas where Scotch broom is already established (most of the colonization forest). Where Scotch broom is not yet present (most of the original forest), a longer cycle should suffice.

Monitoring is a very important component of the restoration effort. The use of permanent plots permits comparison of pre- and post-restoration forest structure. As discussed previously, plots have been established in the colonization forest; more plots will be laid out soon in the original forest. After the first complete round of restoration, all plots will be recensused to ascertain how much progress has been made toward the restoration goals. At that time, I will determine what additional restoration work needs to be done, and I will periodically revisit the plots to see how those efforts succeed.

I will be particularly interested in the following vegetation responses to restoration: First, how much is the density of saplings and pole-size trees reduced? Second, how much is Scotch broom cover reduced? Third, where the ground cover is currently prairie vegetation, does cover of native species increase and that of exotics decrease? Finally, is there an increase in pine seedling establishment?

Fort Lewis' ponderosa pine forest is a unique ecosystem west of the Cascades. Its restoration is a high priority for the Army because it will preserve native biodiversity on the base while simultaneously enhancing military training. If nothing is done, Douglas-fir and Scotch broom invasion will eventually wipe out the native prairie vegetation and threaten the perpetuation of the pine population. Personally, as an ecologist and nature lover, I am excited by the prospect of standing amid a lush cover of native prairie plants, gazing across an all-aged forest of fire-scarred pines to the gleaming dome of Mt. Rainier.

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Figure 1. Major plant communities at Fort Lewis Military Reservation, Washington.

Figure 2. Aerial photos of the Eastgate/B-N area in 1942 and 1995. Note the absence of trees in the area outlined as "colonization" forest in 1995.

Figure 3. Density and basal area of ponderosa pine and Douglas-fir (≥ 5 cm DBH) in the colonization forest. Bars represent means ± one standard error.

Figure 4. Diameter distributions of ponderosa pine and Douglas-fir (≥ 5 cm DBH) in the colonization forest.

Figure 5. Proportion of cone-bearing ponderosa pine trees, by size class.