A FOREST MANAGEMENT STRATEGY FOR THE

FORT LEWIS MILITARY RESERVATION

WASHINGTON

Forestry Program

Environmental and Natural Resources Division

U.S. Army, Installation Management Agency

Fort Lewis Military Reservation

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EXECUTIVE SUMMARY

A Forest Management Strategy for rhe Fort Lewis Military Reservation

Located south of Tacoma, Washington, Fort Lewis encompasses 86,500 acres of national significance, both as an arena for military training and as a landscape of diverse ecosystems. More than 50,000 acres are forested, and are managed by the Fort Lewis Forestry Program. The Public Forestry Foundation received a request from The Nature Conservancy and the Forestry Program to prepare a forest management strategy for the Fort Lewis Military Reservation. The goals of the project were to: (1) substantiate thirty years of sustainable forest management practices, (2) incorporate biodiversity and endangered species into management, (3) reconstruct historical forest conditions, and (4) suggest rational future forest conditions that integrate the functions of the varied forest ecosystems.

The document was completed in 1996, and this revision was prepared by Forestry staff in 2001. This plan guides forest management on Fort Lewis for the next five years.

The document is divided into six major sections:

INTRODUCTION - Summarizes key issues leading to the development of new goals and strategies.

THE FORT LEWIS FOREST - Describes important attributes of the Fort Lewis landscape and provides an assessment of forest conditions in an ecosystem framework.

ECOSYSTEM MANAGEMENT STRATEGIES - Develops strategies for achieving management goals within the ecosystem framework, based on current concepts of ecosystem management.

MANAGEMENT STRATEGIES BY GOAL - Provides qualitative statements of management goals and describes how goals will be achieved by the Strategy or other specific strategies.

IMPLEMENTATION - Describes the process and infrastructure for implementation of management strategies by the Forestry Program.

SUMMARY OF EFFORT AND OUTPUTS - Provides estimates of the expected levels of effort and outputs and describes future forest conditions expected with implementation of the Strategy.

Background And Development Of Goals

The Military mission for Fort Lewis' forests provides opportunity for other goals. The primary mission for the Fort Lewis Forest is to provide a variety of forested environments for military training. This mission, however, provides much opportunity for other forest management goals. New goals and strategies are needed to incorporate updated resource information and to address current issues, including:

- Fort Lewis' designation as critical habitat for the northern spotted owl.
- Emphasis on maintenance and restoration of native biological diversity.
- The need to practice and demonstrate sustainable federal forestry.

Strategies are based on ecosystem management - The evolving concepts of ecosystem management provide the best approach for integrating societal needs and ecological capabilities into the management of the Fort Lewis Forest. Major goals and management direction are derived from the integration of societal desires and ecosystem capabilities at Fort Lewis, as follows:

(1) Develop and maintain late-successional forests in order to:

- Meet the legal requirement to provide for recovery of the northern spotted owl.
- Provide habitat for many species in a landscape devoid of older forests.
- Address both social and ecological needs for maintaining a component of older forest across the landscape.

(2) Maintain and restore native biological diversity and unique plant communities, including:

- Ponderosa pine
- Oregon white oak
- various wetland types
- other minor and rare plant communities

(3) Maintain low risks of catastrophic fire for protection of:

- adjacent human communities
- military training areas
- late-successional reserves
- special or rare habitats of regional value

Active management is needed to meet the goals of ecosystem management over much of Fort Lewis - Many factors that controlled native ecosystems are permanently altered in the modern environment. In the absence of important natural processes, management strategies must emulate natural disturbances to maintain native ecosystems, or provide a new disturbance regime designed to maintain desirable altered ecosystems in a healthy state.

The Fort Lewis Forest

The Fort Lewis landscape was formed by glaciation, ending about 10,000 years ago. The topography is characterized by flat plains and gently rolling terrain, with occasional hilly areas. The majority of the soils are coarse-textured and excessively drained. These factors, combined with dry summers, produce a predominance of dry-site forest conditions, unusual for western Washington.

There are about 54,800 acres of forested lands at Fort Lewis, distributed as follows:

65 percent dry-site Douglas-fir forest

20 percent moist Douglas-fir/cedar/hemlock forest

6 percent Oregon white oak woodlands

3 percent moist hardwood forests of alder and maple

2 percent wetland or floodplain forests of cottonwood, willow, and ash

3 percent ponderosa pine woodlands

Forest harvesting and management practices have sustained and developed a maturing forest, while providing an average annual harvest of 9.1 million board feet of sawtimber during the past 17 years. As of 1993, Fort Lewis had 1.120 billion board feet of standing timber. Between 1985 and 1993, net growth (after harvest) averaged 25.6 million board feet per year. Considering the predominance of dry sites, Fort Lewis' forest stands are quite productive for timber, with an average site index of 112 feet in 50 years

A great diversity of wildlife is fully or partially supported by the varied environments at Fort Lewis. This includes at least 174 species of birds, 57 species of mammals, 17 reptiles and amphibians, and 25 species of fish. Twenty of these are species of concern.

About 58,000 acres of Fort Lewis is designated critical habitat for the northern spotted owl. Although no spotted owls have been found at Fort Lewis, it is the only significant federal ownership in the Western Washington Lowlands. The main recovery goal is to develop suitable owl habitat at Fort Lewis, in hopes of establishing connectivity between owl populations in the Cascade Range and the Olympic Peninsula.

Fort Lewis contains about 1,000 acres of lakes and 3,500 acres of wetlands. Seasonal or semi-permanent wetlands provide a diversity of wetland vegetation types, including about 1,300 acres of forested wetlands. Hydrology and drainage features are dominated by groundwater, due to the excessively rapid drainage of most soils at Fort Lewis.

Direct use of the forest by thousands of military trainees is by far the most significant use of the Fort Lewis Forest by humans. About 20,000 military personnel are expected to be continually stationed at Fort Lewis during the next five years. In addition, residents of adjacent communities frequently recreate the Fort.

Native Americans from the adjacent Nisqually Reservation depend on Fort Lewis' forests for hunting, gathering medicinal and food plants, spiritual activities, and protection of stream corridors for fishing.

A variety of forest products harvested from Fort Lewis benefit people in local communities. Sawtimber harvest has averaged 7.4 million board feet per year since 1993, providing about 3% of the total harvest in Pierce and Thurston Counties. Firewood is collected by soldiers and residents of adjacent communities.

About 800,000 people live in urban and rural communities surrounding Fort Lewis. Fort Lewis expenditures constitute 10 to 12 percent of the total income in Pierce and Thurston Counties.

Fort Lewis Ecosystems

Fort Lewis ecosystems are defined and assessed based on a logical, hierarchical framework for viewing patterns and processes at different landscape scales and ecological levels of organization. Ecosystem conditions and management strategies are summarized for broad vegetation community types and Ecological Landscape Units.

Vegetation community types provide the primary level for characterization of attributes such as disturbance processes, species composition, forest structure, successional stages, and local stability. Broad community types are based on historic and current vegetation types, including:

dry Douglas-fir forest
moist Douglas-fir/red cedar/hemlock forest
White oak woodlands
Ponderosa pine woodlands
wetland/floodplain forests
prairies

The dry Douglas-fir forests consist of two types, Historical Dry Forests that were forested at the time of first European settlement, and Colonization Dry Forests that are the result of conifer invasion of former prairies in the absence of fire.

Ecological landscape units (ELU's) are designated for control and monitoring of landscape level attributes and patterns, such as stand age-class diversity, patch-size, community type composition, landscape stability, spatial patterns of connectivity, and functional interaction between types. Three ELU's are defined for Fort Lewis as follows:

North-Central Fort (NC) ..... 45,540 acres
Northeast Fort (NE) ..... 23,375 acres
Rainier Training Area (RTA) ..... 18,066 acres

Each ELU has a distinct set of conditions that requires different management strategies. The prevailing character of human impacts and continuing needs for military training are important ecosystem drivers incorporated in the determination of ELU's.

Historical ecosystems provide the basis for understanding potential ecosystems and management strategies at Fort Lewis. Both current and historical forest ecosystems at Fort Lewis are characterized by a wide range of potential conditions, dependent on disturbance regimes. Historical ecosystems and their ranges of variation provide the basis for understanding potential Fort Lewis ecosystems under the modern disturbance regime. Management strategies for current ecosystems must be developed within the context of human goals and management capabilities that determine the modern disturbance regime.

Historical ecosystem conditions were controlled by relatively frequent fires. Fires ignited by Native Americans maintained a landscape dominated by grasslands (36% of area), woodlands (13%), and

open, mixed-canopy forests (30%). Moist, dense forests that burned less frequently and more severely occupied about 15 percent of the historical landscape, much of this within the large, contiguous forest in the Rainier Training Area.

Significant changes in ecosystem patterns and processes have occurred under the post-settlement disturbance regime. Closed-canopy forests now dominate a larger and more contiguous portion (60%) of the Fort Lewis landscape. Prairies and woodlands are greatly reduced in extent: 16,500 acres of former prairie and pine/oak savannas have been eliminated by forest invasion. The dominant, Douglas-fir forest canopy is relatively young and lacking in mature forest elements as a result of early logging and forest colonization of prairies.

Post-settlement changes in disturbance included grazing, timber harvest, reduced frequency of prairie fires, and suppression of forest fires. The fire regime is now characterized by frequent small fires, quickly suppressed after accidental military ignitions. Timber harvesting has replaced fire as the primary determinant of forest structure and landscape pattern. The major effect of fire on modern forest conditions arises from the need to maintain low hazards of catastrophic fire.

Ecosystem Management Strategies

Using concepts of ecosystem management, forest management strategies are formulated within the ecosystem framework. Key elements of the ecosystem management approach at Fort Lewis are outlined below.

Conservative and adaptive management - Our ability to understand or even characterize ecosystem functions is not well developed, so the best current strategy for managing ecosystems is a working hypothesis. Relative to historic conditions, the Fort Lewis environment is subject to several persistent new factors:

- periodic mechanical disturbances
- prescribed fires burning under relatively moist conditions
- suppression of fire during low-moisture conditions
- aggressive, exotic plant species

Considering these factors, application of new treatments to maintain or restore “natural ecosystem functions” must be conservative and adaptive. After some time, the effects of management will become apparent and strategies can be improved and applied to larger areas. This process of adaptive management will be based on monitoring of operational effects, as well as incorporation of research findings made in pertinent ecosystems both on and off the Fort.

Multiple scales - management activities will be designed and controlled across multiple landscape scales.

Coarse filter concept - Most native inhabitants of the ecosystem will be ensured appropriate habitat simply by maintaining or restoring a functional range of ecosystem conditions at appropriate scales. Our understanding of the historic range of ecosystem conditions serves as a basis for the “functional” range of conditions. The strategic goals for maintaining mature forests and biodiversity (Sec. III.A.1) provide two of three major strategies for the coarse filter approach at Fort Lewis. The third strategy is maintenance and protection of all waters, wetlands, and riparian zones.

Fine filter concept - Some species of concern require protection and/or enhancement of certain habitat elements. These are discussed for each species of concern in this document, in the Fish and Wildlife Management Plan, and in the Northern Spotted Owl Habitat Management Plan.

Conservation reserves provide for the protection or restoration of critical ecosystems and species habitats, and as reference areas for assessing the effects of management. About 10,200 acres of reserves are designated in this document.

The biggest challenge arises from the desire to maintain contiguous mature forest ecosystems in a fire-suppressed environment, while preventing the accumulation of fuel-hazards conducive to large-scale, catastrophic fires. The general strategy for this is to maintain a landscape pattern of vegetation structure that produces a patchy mosaic of fuels, similar in many ways to the historical fire-driven landscape. In such a landscape, continuing military ignitions should produce frequent fires of variable and moderate intensity that can help maintain the landscape mosaic.

Stand-level planning for future forest conditions employs a long-term, multi-stage approach to achieving the combination of desired structural characteristics. Treatments, primarily variable-density timber harvest, are designed to improve important attributes in the long-term, but may reduce other desirable characteristics in the short-term. Adaptive management derived from experimentation and monitoring is critical to this process.

Strategies and priorities for management treatments are developed for each community type and applied to specific stands, depending on (1) the current structural condition of the stand, and (2) the juxtaposition of other community types and conditions within Ecological Landscape Units.

Dry Douglas-fir forest

About 70 percent of the Fort Lewis Forest is a dry Douglas-fir type. The majority occupies areas that have historically been forested, though at lower tree densities in the past (Historical Dry Forest). About 16,500 acres is Colonization Dry Forest that occupies former prairies and woodlands. The general strategy for most Dry Forests is to emulate processes in natural, dry-site Douglas-fir forests by developing multi-aged and patchy stand structure, maintained by relatively frequent silvicultural treatments (10- to 50-year cycle) and fire disturbances (accidental military ignitions causing frequent small fires).

Dry Forests can provide mature forest structure while maintaining a patchy mosaic of woody fuels, both within and between stands. This is a key element of the strategy for maintaining a fire-resistant landscape within larger contiguous areas of a Dry/Moist Forest matrix, and as part of the forest-woodland-prairie mosaic.

The short-term priority for management is to enhance existing structure in 45- to 85-year-old stands, some of which have residual live trees from previous forests, and allow accumulation of snags and coarse woody debris. The second priority is to initiate structural diversity in younger, even-aged stands, though many of these stands can be allowed to develop large trees and understory structure without entry. Colonization Dry Forests may require special treatments (e.g., heavier thinning) at their ecotones with oak or pine woodlands and prairies.

Moist Douglas-fir/redcedar/hemlock forest

Moist Forests occupy about 25 percent of the forest; these areas were forested at the time of European settlement, but at lower stem densities. The majority of the unreserved Moist Forest is in even-aged stands 45 to 85 years old, with no residual trees. In the short-term, most management actions will be aimed at initiating structural diversity, with treatments to accelerate development of large overstory trees, snags, logs, and vertical and horizontal canopy diversity. Heavier accumulations of coarse woody debris and fuels can be allowed because of the protection from large-scale fire afforded by the landscape mosaic.

About 1,800 acres of hardwood (alder/maple) stands have established after early logging on Moist Forest sites. Two major strategies apply to these stands: (1) allow or facilitate the succession of conifers, especially western redcedar, and (2) retain a component of hardwoods during thinning of both early- and late-successional stands.

Oregon white oak woodlands

Various oak types cover about 3,500 acres, typically as a transitional zone between Dry Forests and prairies. These woodlands were mcuh more extensive in pre-European times. Remnant oak sprouts, saplings, and trees are common in Colonization Dry Forests. The first priority is to maintain intact oak woodlands by removing or preventing further encroachment of Douglas-fir. The second priority is to restore stand structure in degraded oak communities.

Ponderosa pine woodlands

Ponderosa pine occurs in significant proportions on about 1,700 acres. Pine-dominated woodlands occupy about 500 acres; additional pine occur scattered across several prairies, and as residual overstory trees in Colonization Dry Forests. Most existing pine stands have been degraded by conifer invasion in the absence of fire, and by encroachment from exotic species, especially Scotch broom. The first priority is to retain pine within existing Colonization Dry Forests.

The second priority is restoration treatments to restore stand structure in degraded pine woodlands, especially those that retain native prairie understory.

Wetland/floodplain forests

Forests of cottonwood, willow, and Oregon ash occupy about 1,300 acres of both seasonal and perennial wetlands. The largest area of riparian forest lies in the Nisqually Floodplain Research Natural Area (RNA), where natural disturbance processes maintain the ecosystem. Significant areas of wetland forest also occur as scattered patches throughout the Fort. These will continue to be maintained and protected during any management activity in adjacent upland forest.

Prairies

While forest management activity does not directly affect the 20,700 acres of prairie, further encroachment of Douglas-fir will be prevented through prescribed burning and maintenance of ecotones between forests, woodlands, and prairie. Outlying patches of Douglas-fir may be removed in efforts to restore or maintain prairies.

Future Conditions

The assessment of ecosystems developed here helps define the ranges and limits of ecosystem capabilities, *providing an initial basis for new management strategies in the short-term (10-20 years).* It is not appropriate here to make long-term allocation of specific areas to future ecosystem states. Such allocations should be developed from future judgments based on additional experience with ecosystem treatments and responses at Fort Lewis. This is why this document is called a *management strategy*, rather than a plan.

Fort Lewis' ecosystems have been relatively unstable during post-settlement times, with directional change a predominant property of forest stands and landscapes. *These dynamic conditions will continue for the next several decades*. Though a stable endpoint cannot be specified, the short-term management direction is clear, based on the immediate priorities for encouraging mature forest systems in a predominantly young forest landscape, and for restoring declining native communities.

Based on current age structure and rates of tree growth and tree mortality, a rough estimate of the Fort Lewis' capability to develop mature forest cover is about 30,000 acres over the next 50 years. About 25 percent of the maturing forest will be composed of Moist Forest, primarily even-aged Douglas-fir in the overstory, with mixed-age components of intermediate redcedar, bigleaf maple, and hemlock. This Moist Forest will develop in an increasingly stable and uneven-aged matrix of the predominant Dry Forests. The landscape will continue to be resistant to large-scale catastrophic fire, with the maintenance of both the Dry/Moist matrix in contiguous forest and the large-scale, open landscape pattern of interweaving prairies, woodland, and forest.

Existing pine and oak habitats will be stabilized and expanded. Pine and oak trees within colonizing forests currently dominated by Douglas-fir will be maintained. Wetland forests and riparian areas will remain intact.

Implementation

The Forestry Program of the Fort Lewis Environmental and Natural Resources Division has overall responsibility for implementation of this forest management strategy. More detailed plans and documentation have or are being developed from this strategy, including an Oak Woodland Management Plan and a Forestry Monitoring Plan.

The initial approach for prioritizing and selecting areas for treatment builds on the past procedure of identifying candidate stands, which is based on a 10-year cycle for evaluating and treating delineated stand units (734 stands currently delineated). Evaluation and selection of stands relies heavily on the experience and judgment of staff foresters and biologists. They will evaluate the need for treatments, based on application of the Ecosystem Management Strategy, dependent on the specific opportunities indicated by current stand attributes.

Summary of Expected Effort and Likely Outputs

The annual capability for silvicultural treatments will remain in the range of about 2,000 to 2,500 acres under current staffing. In addition, opportunities for supplemental resources from outside sources may arise for cooperative habitat restoration treatments. The approximate areas available over the next decade for active management are as follows:

(1) About 23,500 acres of young forest management units are suitable for initiating structural diversity and accelerating forest succession.

(2) About 12,300 acres are suitable for enhancing existing mature forest attributes, including about 7,900 acres of young forest with residual old trees and 4,400 acres of older forests.

(3) About 7,900 acres are suitable for stocking control and initiation of desirable patterns in regenerating conifer stands.

(4) About 1,800 acres are suitable for facilitating long-term succession to conifers in early-successional hardwood stands.

(5) Rougly 2,800 acres of existing oak woodlands and 500 acres of existing pine woodlands will be maintained or enhanced, and residual oak and pine in 3,200 acres of Colonization Dry Forests will be retained.

The acreages presented above should be used as an initial guide for allocating effort under the Sstrategy. With the current capability for annual treatments, about half of the total available acreage suggested above can be treated over the next decade. This is appropriate for the conservative and adaptive approach to management at Fort Lewis.

Timber harvest volumes resulting from silvicultural treatments will remain in the range of 8 to 10 million board feet per year during the next decade. This is about one-third of the current net increment in volume, since growth of timber will continue to accumulate in the maturing forest.

Poles will be harvested as needed for military activities. *Firewood harvests will be reduced* from the levels of previous decades to provide more input of coarse woody debris, though removal of down wood near roads will continue.

Intensive use of forested training areas will continue, with about 25,000 military personnel to be stationed at Fort Lewis during the next five years.

Traditional uses of the forest by Native Americans from the adjacent Nisqually reservation will continue.

Recreational uses by members of adjacent communities will continue to be allowed in certain forested areas (includes hunting, fishing, hiking, birdwatching, horseback riding).

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PREFACE

A. GUIDING PRINCIPLES

(1) The primary mission of Fort Lewis is military training; thus, a primary goal of forest practices is to maintain a naturally diverse forest environment suitable for a variety of military training exercises.

(2) Military training needs will continue to provide opportunities for maintaining forest structure that are beneficial to many other ecosystem components and values.

(3) An appropriate forest management strategy should provide a framework for integrating diverse goals, be adaptable to new information and to changes in allocation to specific resource objectives.

(4) Sustainable Forestry will continue to be practiced: outputs of extractable resources along with important ecosystem attributes must be sustainable.

(5) Habitat for rare, threatened, or endangered species will be enhanced or maintained in accordance with legal requirements and specific habitat management plans.

(6) Beyond the needs of single species, biological diversity will be maintained or enhanced.

(7) Concepts of ecosystem management will be applied as a framework for strategizing integrated forest management.

(8) Ecosystem management requires that planning and management are carried out in the context of multiple landscape scales from regional to site-specific.

(9) Allocation of effort to the production or maintenance of various resources at Fort Lewis is not driven by economics.

(10) Management will adhere to Forest Stewardship Council (FSC) principles and criteria, maintaining third-party certification as a result.

B. STRATEGY REVISION

The original Forest Management Strategy covered a period of five years (1997-2001); this revision covers the next eight years (2002-2009). In addition, Fort Lewis recently adopted an Integrated Natural Resources Management Plan (INRMP), as required by Army regulations (AR 200-3, 9-4) and the Sikes Act (Public Laws 99-561 and 105-85). The INRMP required preparation of an Oak Woodland Management Plan. This plan was completed in August, 2002, and is incorporated into this revision of the Forest Management Strategy as an appendix.

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I. INTRODUCTION

This document develops updated goals and strategies for the management of forested lands on the Fort Lewis Military Reservation. Fort Lewis is an 86,200-acre military reserve, including 54,400 acres of forest and woodlands. The primary mission for the Fort Lewis forest is to provide a variety of forested environments for military training. This military mission, however, provides much latitude and opportunity for other forest management goals.

A. BACKGROUND

1. THE NEED FOR UPDATED STRATEGIES

In the past, forest management at Fort Lewis emphasized production of timber, control of fire hazards, and maintenance of habitat for game animals, and for sensitive or threatened wildlife (U.S. Army 1976, U.S. Army 1984). Recently, Army forest management guidance has changed to address new goals and issues. In addition, much new natural resource information has accumulated, especially in GIS format. The Forest Management Strategy incorporates updated resource information and addresses a number of new issues, including:

- Fort Lewis' designation as critical habitat for the northern spotted owl.
- Emphasis on maintenance and restoration of native biological diversity.
- The need to practice and demonstrate sustainable forestry and ecosystem management.
- Army guidance that maximizing timber output is not an appropriate management goal.

2. STRATEGIES BASED ON ECOSYSTEM MANAGEMENT

The strategies developed here are based on concepts of ecosystem management. There is growing consensus among scientists and policy makers that the evolving concepts embodied in ecosystem management provide the best approach to integrating the complexity of societal needs and ecological capabilities in the management of forest landscapes. The most basic of these concepts is that truly sustainable outputs of natural resources depend on long-term maintenance of healthy ecosystems.

The need for an ecosystem approach was emphasized by the Deputy Under Secretary of Defense in a memorandum, dated August 8, 1994:

> "I want to ensure that ecosystem management becomes the basis for future management of Department of Defense lands and waters... [Ecosystem management] is a goal-driven approach to restoring and sustaining healthy ecosystems and their functions and values using the best science available. The goal is to maintain and improve the sustainability and native biological diversity of terrestrial and aquatic, including marine, ecosystems while supporting human needs, including the Department of Defense mission. "

The memorandum states the Department of Defense's ecosystem management principles:

- Maintain and improve the sustainability and native biological diversity of ecosystems.
- Administer with consideration of ecological units and time frames.
- Support sustainable human activities.
- Develop a vision of ecosystem health.
- Develop priorities and reconcile conflicts.
- Develop coordinated approaches to work toward ecosystem health.
- Rely on the best science available.
- Use benchmarks to monitor and evaluate outcomes.
- Use adaptive management.
- Implement through installation plans and programs.

The Department of Defense policy was reinforced by Forces Command, which oversees Army installations, in its policy on ecosystem management, issued on January 18, 2001:

"Installations will manage lands for long-term sustainable vegetative cover, giving priority to native species when practical and consistent with the mission … the variety of native habitats will be maintained to support the diverse plant and animal populations which normally occupy these lands."

3. THE NEED FOR ACTIVE MANAGEMENT

Many factors that controlled native ecosystems in south Puget Sound prior to European settlement are permanently altered in the modern environment. Of these now-missing factors, fire was the most important shaper of ecosystem structure. Current conditions throughout the forest are the result of the absence of these factors, and of repeated management entries and other human disturbances in the post-settlement era. In addition, invasion by exotic plants is a relatively new, human-induced ecological factor that is radically altering the structure of prairie and woodland habitats in south Puget Sound. Modern management strategies must emulate natural disturbances and limit encroachment by exotics, to maintain desirable ecosystems in a healthy state. Little or no active management is a viable ecosystem strategy for some areas in which desirable ecosystem conditions are likely to be maintained in the absence of disturbance, or with continued natural processes such as flooding.

4. CURRENT ECOSYSTEM ASSESSMENT: BASIS FOR SHORT-TERM MANAGEMENT

This strategy makes an assessment of ecosystems and presents a flexible, adaptive management framework for sustainable forestry that continues to apply new information as it is updated. The assessment of ecosystems presented here estimates some ranges and limits of ecosystem capabilities, providing the basis for management strategies in the short-term (10 to 20 years). It is not appropriate here to make more specific, long-term allocations or projections of acreages to future ecosystem states. These will be developed from future judgments as part of site-specific planning based on (1) ongoing stand inventory and (2) adaptation of treatments based on experience with ecosystem responses at Fort Lewis.

5. RELATIONSHIP OF STRATEGY TO OTHER PLANS

In 1992, the U.S. Fish & Wildlife Service (USFWS) designated Fort Lewis as critical habitat for the northern spotted owl (Designated Conservation Area WD-43). With this designation, Fort Lewis was required to prepare a habitat management plan for the DCA. The Northern Spotted Owl Habitat Management Plan for Designated Conservation Area WD-43, Fort Lewis, Washington (Owl Plan) was completed in October, 1994 (Bottorff 1994). The Owl Plan simultaneously served as the biological assessment for the original Forest Management Strategy. In September, 1996, the USFWS issued a 5-year, programmatic, informal consultation that approved the Strategy and Owl Plan.

The 1997 amendments to the Sikes Act (PL 99-561, 105-85) require military installations to prepare Integrated Natural Resources Management Plans (INRMPs). Fort Lewis' INRMP was completed in January, 2001, and incorporates the Forest Management Strategy and two other natural resources plans, the Fish and Wildlife Management Plan and the Integrated Pest Management Plan, by reference. The INRMP also required preparation of a Prairie Management Plan (Prairie Plan) and an Oak Woodland Management Plan (Oak Plan). The Prairie Plan, completed in August, 2003, interfaces with the Strategy in two ways: (1) management of forest/prairie ecotones, and (2) use of prescribed fire on prairies. The Oak Plan, completed in August, 2002, is incorporated in this revision as an appendix to the Forest Management Strategy.

B. ACCOMPLISHMENTS DURING THE FIRST EIGHT YEARS

The period covered is January 1997 through December 2004:

Timber Sales

A total of 144 commercial timber sales was harvested. These encompassed 18,621 acres, with a total wood volume of 58.3 million board feet (mmbf). One-hundred sixteen sales (14,728 acres) were variable-density thins, nineteen sales (2,751 acres) were combination cuts, four sales (222

acres) were alder removals, two sales (153 acres) were designed primarily to release oak, and two sales (884 acres) removed trees from prairies. An additional 3.5 mmbf was harvested in miscellaneous sales, mostly for facilities construction. Average annual harvest was 7.7 mmbf per year.

Reforestation

A total of 645 acres of plantations received site preparation treatments (brush removal, soil scarification) and 729 acres were planted. In addition, 120 acres of precommercial stands were thinned and 1,787 acres of partially-cut conifer stands were planted with various species.

Prescribed Fire

A total of 6,581 acres were burned. Of these, 2,888 acres were prairie restoration, 242 acres oak woodland restoration, 543 acres ponderosa pine savanna restoration, 2,783 acres fire hazard reduction, and 125 acres firefighter training. All of these burns killed substantial amounts of Scotch broom.

Ecological Restoration

A total of 661 acres of ponderosa pine forest and savanna received treatments designed to remove competing tree species, control invasive shrubs, and encourage, where present, growth of native prairie species. The treatments consisted of slashing young Douglas-fir, commercial harvest or girdling of large Douglas-fir, and mowing Scotch broom. These treatments were followed up with prescribed fire, and in one area, planting of pine seedlings from locally-collected seed.

Two timber sales were completed whose primary purpose was oak release through the removal of competing Douglas-fir. These sales totaled 153 acres and 0.66 mmbf.

Inventory and Monitoring

The Intensive Stand Inventory (ISI) was extensively revised in 1998, and a new ISI began in summer 1999. The first round (5 years) of the ISI was completed in September 2003. It measured 67 stands covering 6,057 acres and a variety of forest types. The variables monitored included tree density and basal area, cover and species composition of different forest layers, logs and snags, commercial wood volume, and topography. The first remeasurements occurred in 2004, using a revised protocol that dropped commercial wood volume and added vigor of natural regeneration in the forest understory as a measured variable.

A study was completed, in cooperation with the U.S. Forest Service and the University of Washington, on the utility of lidar (light detection and ranging) remote-sensing technology for monitoring forest stand structure. Lidar can efficiently estimate overstory canopy cover and canopy gaps, but errors are large for cover of understory vegetation layers.

Research

Several of the suggested topics for future research in Appendix F of the original Strategy were or are being addressed. The current range of conditions for ponderosa pine has been characterized, and various restoration techniques have been tested. Ahrens (1998b) characterized tree mortality rates and snag and log accumulation at Fort Lewis. The ecology of Fort Lewis' dry Douglas-fir forests was summarized by Ahrens (1998a); the same study described the structure of a 400-year-old, late-successional stand, Ellsworth Woods. On-going research by the U.S. Forest Service is characterizing the responses of stand structure, spotted owl prey species, and soil communities to stand manipulation, including variable-density thinning. A separate Forest Service study is examining the ecology and management of oak woodlands, including the response of oaks to release. A new Forest Service study is examining the growth and vigor of natural regeneration of Douglas-fir in the understory and canopy gaps of Fort Lewis' colonization forests. Several Nature Conservancy projects have examined various techniques for Scotch broom control and Oregon white oak regeneration.

Certification

It is the stated policy of Fort Lewis Public Works to commit to a philosophy of sustainable environment. The Forestry Branch decided to support that philosophy by pursuing third-party certification of its management. The Forest Stewardship Council (FSC), an international organization, has promulgated the most stringent and widely-accepted standards for forest certification. Fort Lewis contracted with Smartwood to perform an audit to FSC standards. In March, 2001, the field evaluation was conducted, and in April, 2002, Fort Lewis was certified as a sustainable forest.

II. THE FORT LEWIS FOREST

A. LOCATION

Fort Lewis is a contiguous area of land located at the southeastern edge of Puget Sound, due south of Tacoma, Washington (Figure 1). It is in the central portion of the Puget Trough physiographic province (Franklin and Dyrness 1988) at the southernmost margin of a landscape directly shaped by the last continental glaciation. Adjacent physiographic provinces are the Southern Washington Cascades to the east and south, the Olympic province to the northwest, and the Washington Coast Ranges to the southwest.

B. LANDSCAPE

1. CLIMATE

The climate of the Fort Lewis region is characterized by mild, wet winters and warm, dry summers. The average annual precipitation at Fort Lewis is 40.2 inches, with about 70 percent of the annual rainfall occurring between mid-October and February. The driest months are July and August, with an average of only 1 inch of precipitation per month. Average snowfall at the installation rarely exceeds a few inches. Temperatures range from a monthly mean of 36.5 ^{o}F in winter to 65 ^{o}F in summer. The frost-free season averages 176 days (U.S. Army Corps of Engineers 1994).

Climatic conditions at Fort Lewis are determined, in large part, by three factors: the Pacific Ocean, the Olympic Mountains, and semi-permanent high- and low-pressure weather cells which hover over the North Pacific Ocean (Kruckeberg 1991). The Pacific Ocean moderates temperatures in the region and the semi-permanent pressure cells direct maritime air and moisture towards Puget Sound (Kruckeberg 1991, U.S. Army Corps of Engineers 1994). Fort Lewis lies in the rain shadow of the Olympic Mountains, and annual precipitation is quite low compared to many forested areas in western Washington. Average precipitation in the Puget Sound basin ranges from 33 inches in Bellingham to 52 inches in Olympia (Franklin and Dyrness 1988).

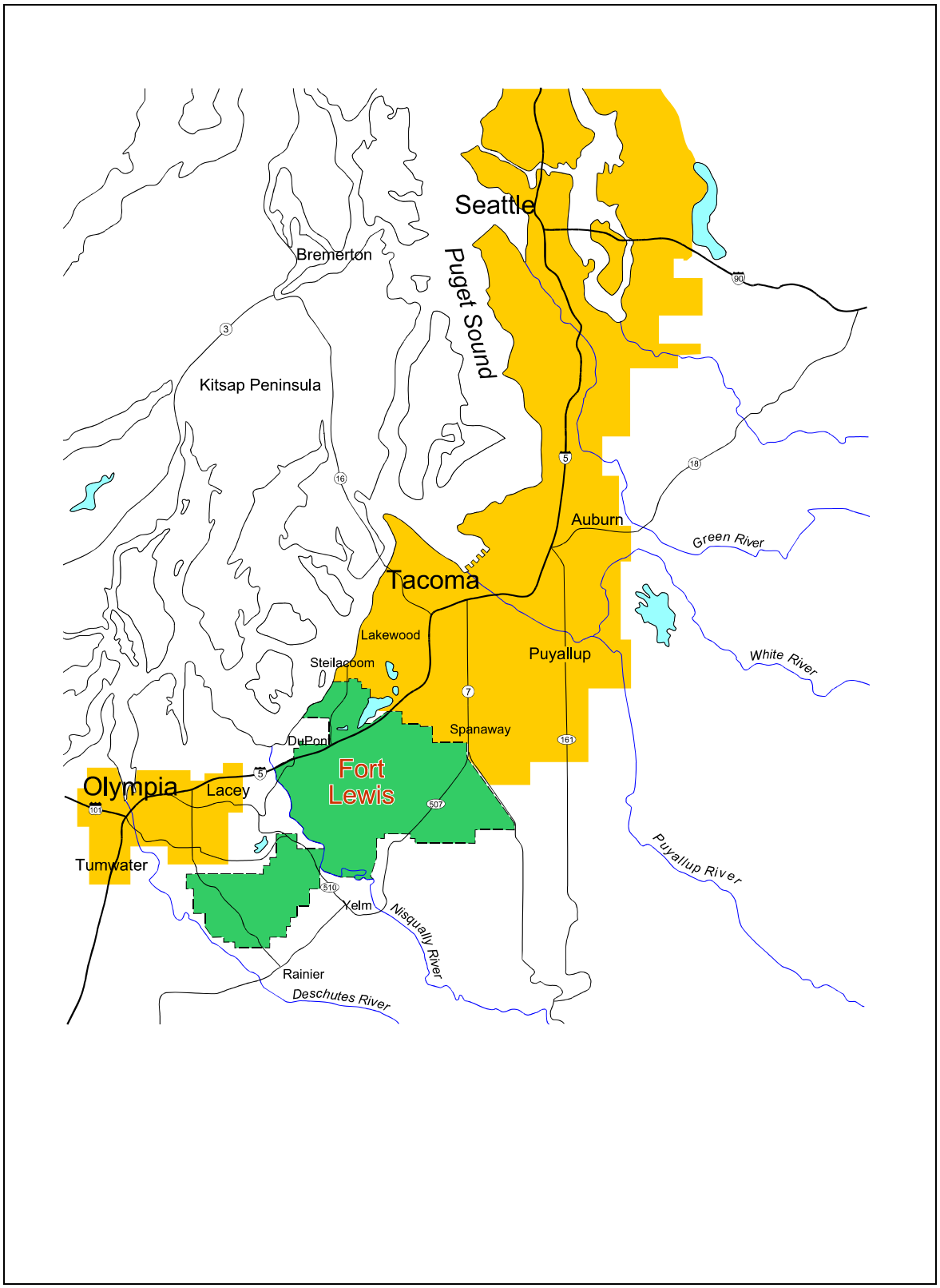
2. GEOLOGY

The geology of Fort Lewis is dominated by continental glacier deposits from the Fraser Glaciation (Walters and Kimmel 1968, Thorson 1980). The geologic units underlying the Fort were deposited by the Vashon Stade of the Fraser glaciation about 14,000 years ago. The Puget Lobe of the glacier reached its terminus just a few miles south of the Rainier Training Area boundary near the current site of Tenino, WA (Kruckeberg 1991).

During subsequent deglaciation, glacial sediments were deposited to form a variety of distinct glacial landforms. A recessional moraine, consisting of ice-contact stratifed drift, was deposited between two sublobes of the continental glacier, in what is now the northern half of the Rainier Training Area (Thorson 1980); its surface is characterized by karst-like topography. The low hills in the western half of the Pierce County portion of the Fort are made of lodgement till (deposited underneath the glacier) mantled with ablation till (surface debris let down onto the landscape as the ice melted away). On some of the hills, the Vashon till may overlie drumlins formed during pre-Vashon glaciation.

The majority of the Pierce County portion of the Fort consists of outwash deposited by meltwater from the receding terminus of the glacier (Walters and Kimmel 1968, Thorson 1980). These deposits were subsequently reworked by water draining from glacial Lake Puyallup, which occupied the Puyallup Valley to the northwest during deglaciation. Braided streams crisscrossing the outwash created numerous swales and stream terraces. Isolated blocks of ice embedded in the outwash melted to form kettle depressions. The resulting topographic surface is called the Steilacoom Plains, underlain by Steilacoom Gravel. Outwash was also deposited in the southern half of the Rainier Training Area. This recent glacial landscape has been modified by post-glacial geomorphic processes of erosion and alluvial deposition, most notably near the Nisqually River and Muck Creek. Lake deposits also formed during and after glaciation in upland depressions in the till and moraine.

Figure 1
Location of Fort Lewis Military Reservation in the Southern Puget Sound Region



Source: ENRD, Forestry Program.

3. TOPOGRAPHY

Topographic characteristics are largely determined by the recent glaciation described above. Due to the predominance of outwash deposits, the topography at Fort Lewis is generally quite gentle, characterized by flat plains and gently rolling terrain with occasional hilly areas of moderate slope. Elevation ranges from 0 to 600 feet, with most of the area between 200 and 400 feet. Short (< 200 feet), steep slopes occur between different levels of outwash terraces and on the banks of old outwash channels. Relatively gentle hills in and around the developed area of Fort Lewis derive from till deposits. The complex, moderately steep terrain of small ridges, hills, and depressions in the north Rainier Training Area is derived from moraines and kettle-kame features.

Topographic features due to surface drainage and erosion are poorly defined because of the highly permeable nature of the coarse-textured soils and glacial parent materials. Exceptions are the steep slopes occurring along escarpments bordering the Nisqually River and the shoreline of Puget Sound. The Nisqually River valley was carved by large volumes of water from the Nisqually Basin, draining around the southern end of the receding Vashon glacier.

Summaries of slope class show the following distribution of slope steepness: Seventy-five percent of the forested land is very gentle with slopes less than five percent. An additional 20 percent of the forest occurs on slopes of 6 to 15 percent. Slopes steeper than 15 percent occur on only five percent of the forested land.

4. SOILS

The soils of Fort Lewis are placed into major groups for general characterization (Figure 2, Table 1), based on maps and descriptions of soil series prepared by the Soil Conservation Service (Anderson et al. 1955, Pringle 1990). Groups I and II comprise 90 percent of the total area and are similar in many physical characteristics (derived from loose glacial sands and gravels, somewhat excessively drained, low water-holding-capacity, coarse textured, and shallow). However, Group I soils developed on outwash plains under prairie vegetation while Group II is strongly associated with the hills or breaks in topography historically occupied by forest. Landscape distribution and other attributes of these soil groups are discussed further in later sections on vegetation, timber, and ecosystems.

5. WATER

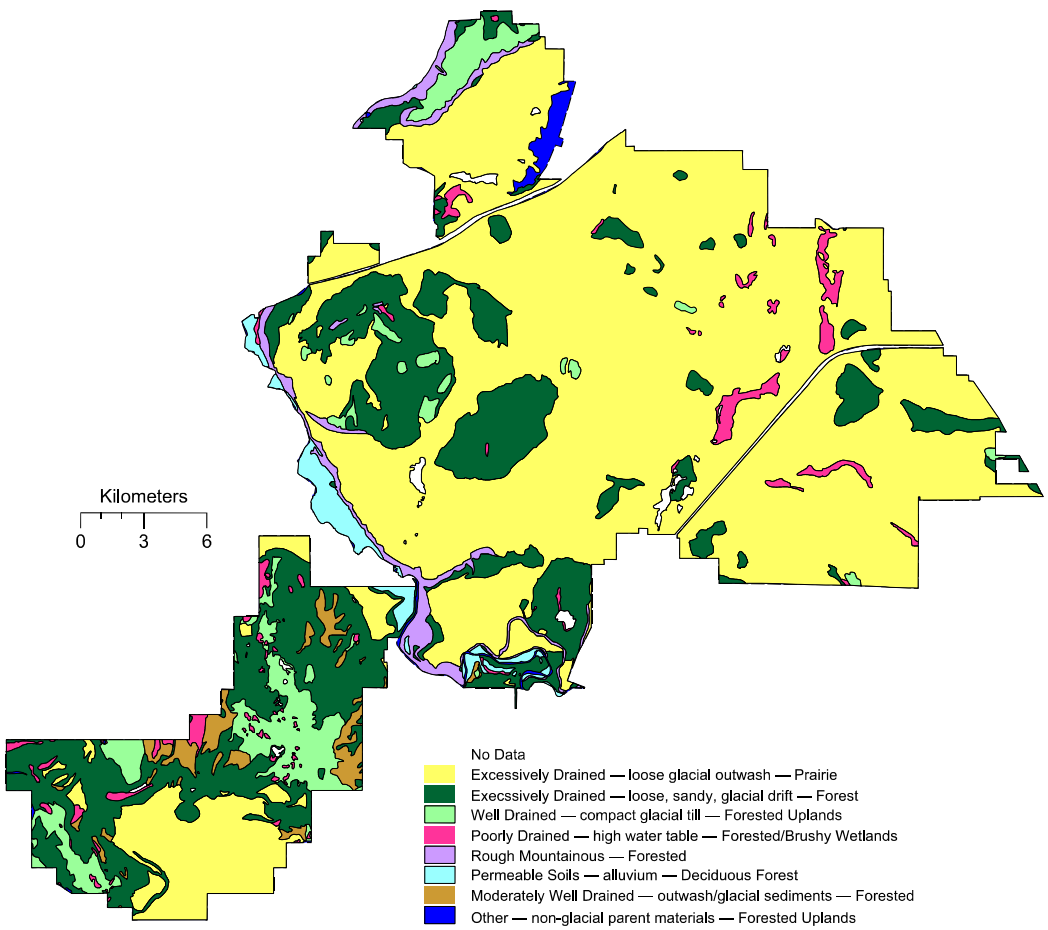
Surface Water

Surface waters and drainage basins of Fort Lewis are shown in Figure 3. Four major surface water drainage basins occur on Fort Lewis: the Nisqually River, Deschutes River, Chambers Creek, and American Lake. Due to gentle topography and very permeable soils, surface water runoff is very low; there are few perennial streams, and surface water sub-basins are poorly defined. Subsurface drainage is predominant and is determined by the topography of impermeable strata at varying depths below the ground.

About 56 percent of Fort Lewis (48,500 acres) falls within the Nisqually River drainage. The Nisqually flows through the Fort for 15.5 miles in a northwesterly direction, discharging into Puget Sound at the Nisqually Reach. Muck Creek is the only stream of substantial length on the Fort and it drains the major surface water sub-basin of the Nisqually within the Fort. About 84 percent of the Muck Creek basin lies on Fort Lewis (30,200 acres). The remainder of Muck Creek basin lies upstream of the Fort, draining rural residential lands with some grazing and forestry uses. Muck Creek flows through or drains several important marshes and lakes (Shaver Lake, Chambers Lake, Dailman Lake, Hamilton Lake, Johnson Marsh, Halverson Marsh). South Creek and Lacamas Creek are small tributaries of Muck Creek.

The Sequalitchew Creek basin of the American Lake watershed occupies about 17,700 acres in the northern part of Fort Lewis. Sequalitchew Creek is a small marshy stream four miles in length emptying directly into Puget Sound on the west side of the North Fort Cantonment area. Originating from Sequalitchew Lake, the creek is the only surface water outlet for the American Lake watershed. Murray Creek, a short stream of about three miles, feeds into American lake,

Figure 2
Distribution of Soils at Fort Lewis



draining the cantonment area and a small amount of forest north of the Central Small Arms Impact Area.

Source: Reclassification of soil series mapped by the Soil Conservation Service, Soil Surveys of Pierce County (Anderson et al. 1955) and Thurston County (Pringle 1990).

Table 1
Classification of Fort Lewis Soils into General Groups

Group I (67 percent of total acreage) Somewhat excessively drained soils derived from loose glacial outwash. Mostly gravelly sandy loam, some sandy loam, or sand. Shallow to moderately shallow. Developed primarily under Prairie vegetation; sometimes under woodland vegetation. Soil series: Spanaway (88), Fitch (7), Nisqually (5)[1]
Group II (22 percent of total acreage) Somewhat excessively drained soils derived from loose, gravelly or sandy glacial drift. Often overlying till or moraine. Mostly gravelly sandy loam, some very gravelly or stony. Very shallow to moderately shallow. Developed under forest vegetation. Soil series: Everett (94), Indianola (5), Lynden (0.8), Skykomish (0.05)
Group III (5 percent of total acreage) Well drained soils derived from compact glacial till. Gravelly loam or gravelly sandy loam. Cemented layer. Moderately shallow. Forested uplands. Soil series: Alderwood (41), Tenino (38), Sinclair (20), Baldhill (0.15)
Group IV (2 percent of total acreage) Somewhat- to very- poorly drained soils: high water table in upland depressions or alluvial bottomlands, including organic muck or peat. Soil series: Semiahmoo (29), Mukilteo (19), Skipopa (7), Tanwax (5), McKenna (5), Kapowsin (4), Bellingham (5), Tisch (3), Shalcar (2), Greenwood (2), Snohomish (0.2), Rifle (0.1)
Group V (2 percent of total acreage) Rough mountainous land, steep escarpments falling to Nisqually river or Puget Sound. Soil series: none described
Group VI (1.5 percent of total acreage) Permeable soils derived from recent alluvium, subject to seasonal flooding or high water table. Silt loam, fine sandy loam, sandy loam. Shallow to deep. Soil series: Pilchuck (77), Puyallup (17), Riverwash (5), Sultan (.75).
Group VII (1.6 percent of total acreage) Moderately- to well-drained soils developed on terraces of outwash or glacial sediments. Fine-sandy loam, silt loam. Deep to moderately deep. Soil series: Yelm (81), Hoogdal (9), Cagey (4), Giles (2)
Group VIII (less than 0.1% of total acreage) Other soils occurring on minor inclusions of non-glacial parent materials. Soil Series: Melbourne (89), Cathcart (11)

Source: Developed from soil series and color groupings described in USDA Soil Conservation Service soil surveys of Pierce County (Anderson et al. 1955) and Thurston County (Pringle 1990). [1]Numbers in parentheses = percent of area within each group comprised of each soil series.

About 6,260 acres of northeast Fort Lewis fall within the Spanaway Creek basin of the Chambers Creek watershed, which drains directly into Puget Sound via surface and ground water. Fort Lewis contains the upstream half of the Spanaway Creek watershed and provides a significant portion of the forested area in this urbanized basin. A formal groundwater management plan for Chambers Creek basin is administered by the Tacoma-Pierce County Health Department.

South of the Nisqually River, groundwater originating on Fort Lewis surfaces just outside the Fort boundary or seeps directly into the Nisqually River. Surface water basins are defined topographically, but there are no substantial surface streams south of the Nisqually River within the Fort boundary. Based on topography, about 7,900 acres of Rainier Training Area (RTA) fall within the Nisqually River watershed, primarily as part of the Thompson Creek sub-basin. Another 10,600 acres of the RTA are in the Skookumchuck Creek and Spurgeon Creek sub-basins of the Deschutes River drainage.

While surface streams are rare across the landscape, lakes, marshes, and wetlands are frequent. The Fort contains about 1,000 acres of named waters including six lakes or marshes larger than 100 acres. Many lakes and marshes are surface expressions of ground water and have no inlet or outlet streams. These may act as groundwater discharge or recharge areas, depending on seasonal changes in the water table and the direction of groundwater flow. Seasonal or semi-permanent wetlands cover about 3,500 acres and provide a diversity of wetland vegetation types.

Groundwater

The flow of groundwater underlying Fort Lewis is controlled by a system of hydrogeologic units consisting of alternating aquifers (water-bearing strata of sand and gravel) and aquitards (strata composed of silts and clays, not capable of producing significant amounts of water). These have been characterized on both a regional (Brown and Caldwell 1985) and a site-specific scale Envirosphere Co. 1988). Depth to groundwater in the unconfined aquifers (ground water levels are below the top of the aquifer) throughout Fort Lewis ranges from 10 to 30 feet, with lesser depths near lakes and streams and greater depths beneath the hilly areas. The remaining aquifers are characterized by low-permeability aquitards and contain groundwater under confined conditions. Confined aquifers are generally less susceptible to surface sources of contamination than unconfined aquifers (U.S. Army Corps of Engineers 1994).

Water Quality

The water quality of all streams on Fort Lewis is classified as extraordinary (AA) or excellent (A) by the State of Washington (U.S. Army Corps of Engineers 1994). The potential for adverse impacts on water quality resulting from forest management is very low due to (1) low erosion rates on predominantly gentle slopes, (2) highly permeable soils, and (3) the predominance of thinning and selective-harvest practices that maintain vegetative cover. Although forest areas are well-roaded, the siltation and turbidity often associated with forest roads is relatively minor due to the gentle slopes and rapid percolation of most runoff from road surfaces.

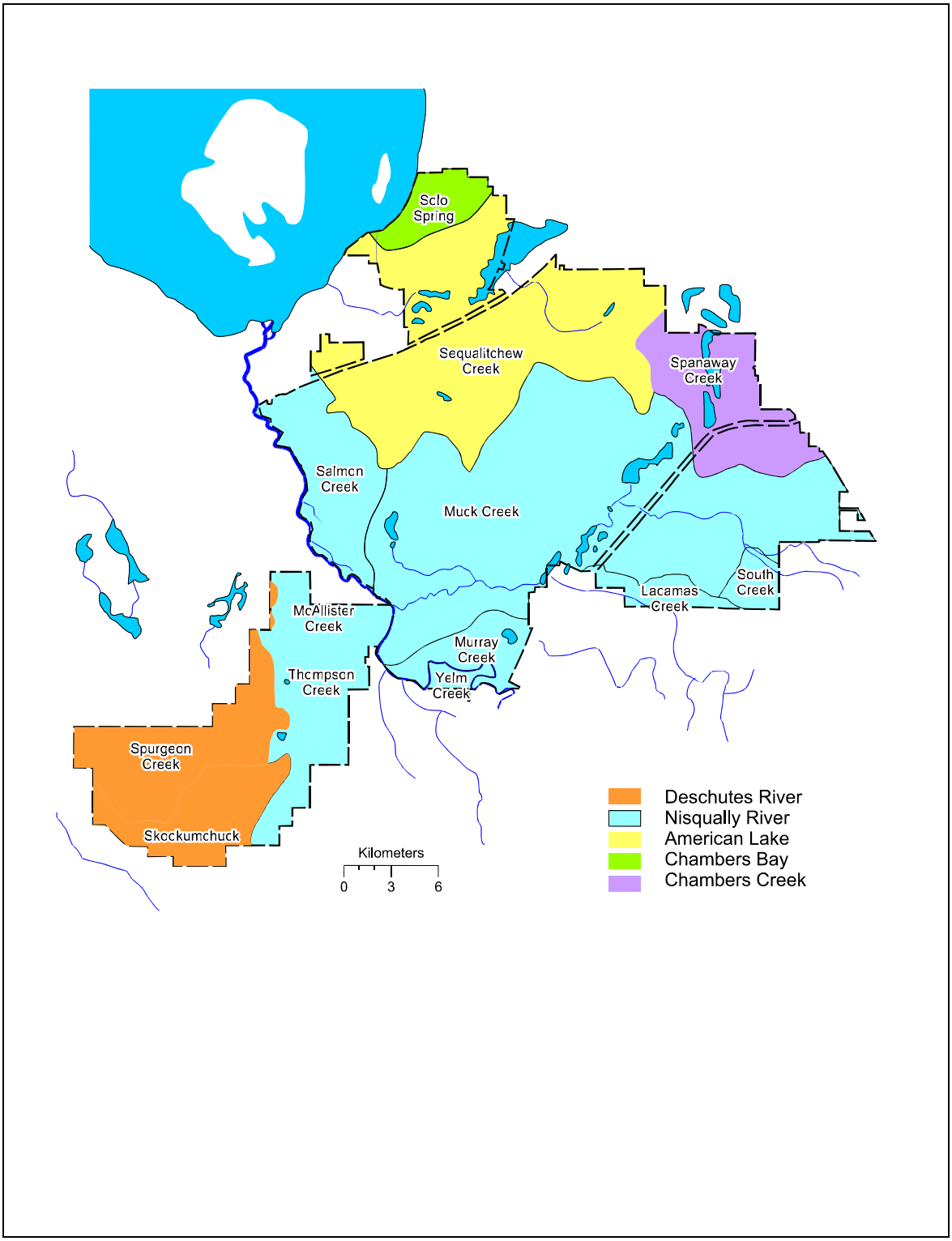
The groundwater in the Fort Lewis area is generally low in total dissolved solids and shows a predominance of calcium and bicarbonate as major constituents, associated with lower concentrations of magnesium, sulfate, and chloride (Brown and Caldwell 1985).

Specific areas beneath Fort Lewis have been affected by waste disposal, leakage, and spilled chemicals. However, monitoring records for the Fort Lewis water system indicate that it is in compliance with requirements for water supplies (Gray and Osborne, Inc. 1991).

Water Supply

Water supplies to the Fort Lewis community are directly dependent on groundwater. The majority of the groundwater supplied to Fort Lewis is provided by Sequalitchew Spring, located between Sequalitchew Lake and American Lake. The cantonment system, which supplies the majority of groundwater for consumption and non-potable uses at Fort Lewis, contains eight wells (including Sequalitchew Spring) and has a capacity of approximately 19 million gallons per day (mgd) and a storage capacity of 6.9 (mgd).

Figure 3
Waters and Watersheds of Fort Lewis



Source: Geographic data on file, ENRD GIS group.

Groundwater recharge, on a regional scale, originates as precipitation on the western flank of the Cascade Mountains, and is transmitted in a generally westerly direction through the hydrostratigraphic system. It discharges to the Puyallup and Nisqually River valleys and Puget Sound. Local recharge of groundwater is provided by infiltration of precipitation, stormwater runoff, wastewater disposal, and reaches of lakes and streams that lie above the prevailing water table (U.S. Army Corps of Engineers 1994). Transpiration by foliage and evaporation of water intercepted by foliage reduces the amount of precipitation that reaches groundwater supplies, probably substantially, although no estimates are available.

Watershed Analysis

Fort Lewis occurs in three Watershed Analysis Units (Muck Creek, McAllister Creek, and Chambers-Clover) as delineated under a recent Washington Forest Practices program. Under this program, the state of Washington has been divided into approximately 400 watershed analysis units (WAU's) ranging in size from 10,000 to 50,000 acres. The watershed analysis process (Washington Forest Practices Board 1993) was instituted with the Timber/Fish/Wildlife Agreement in 1987, amending the Washington Forest Practices Act of 1974 that authorized state regulation of forest practices on Washington's 12.5 million acres of state and private lands. Watershed analysis based on preliminary WAU's was recommended as an approach to deal with cumulative effects of land management at a landscape level. This process has not been applied to WAU's in Fort Lewis nor to any other significant federal acreages.

6. AIR

Fort Lewis' forests affect air quality in two major ways: (1) Forest vegetation improves air quality by absorbing gaseous pollutants and capturing particulate matter (PM). (2) Smoke from accidental and prescribed burning in the forest reduces air quality, primarily by emissions of PM. The forests and prairies of Fort Lewis help reduce airborne pollution in Puget Sound region. Oxides of nitrogen and sulfur from the combustion of fossil fuels are transferred to forests from the atmosphere via wet and dry deposition, subsequently entering into ecosystem nutrient cycles (Waring and Schlesinger 1985). Fort Lewis is one of the largest, contiguous forested areas along the highly developed Interstate 5 (I-5) corridor. As urban development continues to expand, these forests may become increasingly important to maintaining healthy air quality in the Puget Sound region.

Stagnant air conditions can be a problem in the Puget Sound basin, particularly in winter when persistent high-pressure cells concentrate smog near the ground; only an increase in wind speeds or a weather system moving in from the ocean will disperse the stable, polluted air mass (U.S. Army Corps of Engineers 1994, Kruckeberg 1991). The primary air quality concern at Fort Lewis, and in the Puget Sound region, is pollution associated with vehicular emissions: carbon monoxide(CO), nitrogen oxides (NO_x), PM, and ozone (a secondary pollutant created by a chemical reaction between NO_x, volatile organic compounds (VOC's), and sunlight). Standards for permissible levels of these pollutants (National Ambient Air Quality Standards) are set by the U.S. Environmental Protection Agency (EPA), with local jurisdiction given to the Washington Department of Ecology and Puget Sound Clean Air Agency (U.S. Army Corps Of Engineers 1994).

The northwest portion of Fort Lewis is part of a region that was in non-attainment, but is now in attainment, based on the national ambient air quality standard for CO. Fort Lewis is operating under a maintenance plan, approved by the EPA, which outlines how the CO levels will be maintained. Under this plan, outdoor burning is restricted from November 1 to February 28 in the northwest part of Fort Lewis, and year-round in the North Fort and Main Cantonment areas, to help maintain regional air quality in conformance with the standards for CO and PM. Silvicultural burning (e.g., slash reduction) is permitted outside of these areas, normally in the spring or early autumn, when meteorological conditions will usually disperse smoke. Burning is closely coordinated with DNR Smoke Management and the Puget Sound Clean Air Agency. Accidental fires are the most significant sources of smoke in summer.

The major, stationary-point sources of air pollution are combustion devices, such as boilers and emergency generators, which emit sulfur oxides, NO_x, CO, PM, VOC's, and hazardous and toxic air pollutants (as defined, respectively, by the Federal and State governments). Additional point sources of VOC's include painting operations, gasoline storage and transfer facilities, and

degreasing operations. Other major sources of PM are dust and smoke from military training and woodworking operations (U.S. Army Corps of Engineers 1994).

C. FOREST HISTORY

1. PRE-SETTLEMENT FOREST CONDITIONS

Various sources have described historic patterns of dominant vegetation and fire regimes for the Fort Lewis region, based on pollen records, charcoal deposits, and paleoclimatic simulations (Hansen 1947, Hibbert 1979, Heusser et al. 1985, Barnosky et al. 1987, Brubaker 1991). Pollen records indicate that 10,000-12,000 years ago, Fort Lewis was at the southern margin of a forested zone characterized by western hemlock, mountain hemlock, Douglas-fir, Sitka spruce, grand fir, red alder, and Sitka alder.

These forests disappeared from the south Puget lowlands during the much warmer, drier climate about 10,000-6,000 years ago. During this period, the area was characterized by extensive grasslands and oak woodlands, severe summer drought, and frequent, low-intensity fires. Grasslands probably dominated the extensive areas of coarse outwash in the Fort Lewis region. Woodlands would have occurred on less-droughty soils and topography associated with glacial till, moraines, and sediments. Douglas-fir may only have occurred on the best microsites. Mesic trees such as alder, cottonwood, and willow were confined to riparian zones and the wet glacial depressions that currently hold lakes and wetlands.

The forest conditions encountered by the first Euro-American settlers became established beginning about 6,000 years ago. At about this time, there was a regional shift towards more mesic forest vegetation, less frequent fires, and a cooler, moister climate. In the Fort Lewis area, Douglas-fir and oak increased, and grasses decreased. Native Americans had a continuing influence on ecosystems throughout this period, primarily via the maintenance of an annual or semi-annual fire regime and perhaps also via spreading of oak acorns (Taylor and Boss 1975, White 1980, Agee 1993, van Perdue 1997). Oak woodlands are associated with Native American occupation patterns in the Pacific Northwest, and oak trees and acorns were clearly important components of Native American land use.

The pre-settlement landscape is approximately represented by forest conditions mapped by the General Land Office in the 1850's-1870's (General Land Office 1853, 1870). At this time, forests covered about 47 percent of the landscape, oak woodlands or savannas covered 13 percent, and prairies covered 35 percent. Recently burned timber occurred on about 23 percent of the forest area (Appendix C-1).

Under a frequent-fire regime with little soil disturbance, prairie and woodland vegetation is stable and resistant to invasion by Douglas-fir, even though other factors may be favorable for forest growth. Thus, a relatively stable mosaic of grassland, woodland, and forest was probably maintained over this landscape during the last 3,000-4,000 years, as is generally supported by paleobotanical records.

Fire and Other Natural Disturbances

There have been no studies of pre-settlement fire history at Fort Lewis and few old trees are available for dendrochronological study. Probable historical fire regimes at Fort Lewis are proposed here (Table 2) based on (1) reconstruction of past vegetation types from old survey notes and field observations, and (2) fire regimes characterized by Agee (1991, 1993) for typical vegetation types.

Seasonal and permanent flooding has maintained and should continue to maintain distinct forest and brush communities associated with bottomlands along the Nisqually River, Muck Creek, and other minor drainages, and also in upland depressions and marshes.

Wind and windstorms of varying intensity play an important role affecting the form and survival of trees at Fort Lewis. The abundance of exposed margins between dense and open forests, woodlands, and prairies results in a relatively high frequency of wind-formed trees. Occasional high winds have always been a factor producing breakage and windthrow. Along with root

diseases, such as *Phellinus weirii*, these events provide diverse openings and contribute significant inputs of woody debris in unburned forests.

Table 2
Fire-Return Intervals for Major Vegetation Types

Vegetation Type	Fire Return (years)
Moist Conifer Forests	150-300
Dry Conifer Forests	25-150
Douglas-fir/Oak Woodlands	10-50
Ponderosa Pine/Douglas-fir/Oak Woodlands	5-25
Prairies	1-5
Forested Wetlands and Floodplain Forests	usually not fire-regenerated

Source: Interpretation of Fort Lewis conditions based on Agee's (1991, 1993) discussion of fire regimes for major vegetation types in the Pacific Northwest.

2. POST-SETTLEMENT FOREST CONDITIONS

Early Settlements

The earliest effects of Euro-American settlers on Fort Lewis Forests began with the alteration of disturbance regimes on the prairies and forest margins. With the displacement of Native Americans, the frequency of fires on prairies and woodlands was reduced. Reduced fire frequency, and, to a lesser extent, soil disturbance from grazing, was probably the major cause of the accelerated expansion of forests onto prairies and woodlands, a process which continues today.

Settlement of the Fort Lewis region began in the early 1830's when the Hudson Bay Company (HBC) established farms at Fort Nisqually (Dupont) and Cowlitz Prairie (Toledo) (Highsmith and Kimmerling 1979). HBC later formed a subsidiary to expand its agricultural operations; the Puget Sound Agricutural Co. established farms on prairies that are within present-day Fort Lewis (Griffin 1993). The extensive prairies on gravelly or stony soils were used primarily for grazing of cattle and sheep. From 1841 to 1846 the HBC grazed 11,000-18,000 head of cattle, sheep, and horses (Meeker 1905, Hunt 1916). Crops were grown in the better soils along Johnson Marsh. The rate of settlement was slow until the late 1840's. Although specific numbers are not available, it is generally stated that the number of farms and livestock "increased accordingly" with the establishment of the Washington Territory and the subsequent Donation Land Claim Act, which guaranteed "160 acres of land to each bachelor and 360 acres to each married man."

Military Installation

The original military installation of Camp Lewis was established in 1917 on about 67,000 acres (west of the Burlington Northern Railroad) acquired by land-grant from Pierce County (Maris 1991, Griffin 1993). In 1926, the post was renamed Fort Lewis and construction of facilities proceeded steadily on the northwest portion of the installation, with accelerated development during World War II. During this time, additional lands east of the railroad were obtained, primarily by condemnation. During World War II, 17,160 acres of cut-over forest south of the Nisqually River (Rainier Training Area) were acquired from Weyerhaeuser Company and other private owners.

Fire

Although prairie fires were infrequent compared to pre-settlement conditions, fire continued to play a major role in the forest during the time between settlement and establishment of the military installation. Extensive forest fires were noted in 1853, 1868, and particularly in 1902, which was a severe fire year throughout the Northwest (Morris 1934, Lang 1961). Increased fuels from logging

slash and additional ignition sources from the settlers may even have increased the occurrence and severity of forest fires. Most of the Rainier Training Area burned after logging (completed by about 1930).

Since acquisition by the military, extensive fire protection has greatly altered the incidence of fire across the entire Fort, and particularly in the forests. Records maintained since 1944 show an average of only 72 forest acres burned, in spite of frequent ignitions caused by military exercises. Based on the fire frequencies posed earlier, natural fires may have burned an average of 300 acres/year, with relatively large acreage's (1,000's) burning in extreme years. The managed forest fire regime is less variable, with the largest annual burned acreage being less than 500 acres. A typical fire-year is characterized by numerous small fires (quickly extinguished) from accidental military ignitions.

A major consequence of the absence of fire has been colonization of 16,500 acres of former prairie (Type I soils) by Douglas-fir forest (Foster and Shaff 2003). This process is visualized by comparing aerial photographs taken in different years (Figure 4).

History of Forest Harvesting

Logging in the Fort Lewis region began around 1890 along the Nisqually River and in the more accessible portions of the Rainier Training Area. By 1910, nearly all of the Fort's timbered areas were accessed by logging railroads and most of the timber had been cut by the time of military acquisition. Most of the Rainier Training area was logged during the 1920's and 1930's.

The military continued to harvest timber, employing both clear-cutting and more selective harvest techniques. Much of the Argonne Forest area had been cut and burned repeatedly prior to 1910 and the Army resumed clearcutting here in 1934-35. From 1947-1952 the Portland District, Army Corps of Engineers, Lumber Procurement Branch harvested 121 million board feet from Fort Lewis (Table 3). Clearcutting was conducted in areas designated for development, including Davis Woods, Mitchell Woods, Clayton Woods, Hardy Hill, and the McChord strip. In other areas, individual-tree and group selection methods were employed, leaving trees of better form and growth for the future. A decade of reduced harvests followed this intensive cutting. During this time, harvests consisted of salvage logging, stand improvement, and some clearing for new construction. Salvage logging in the aftermath of Hurricane Freda (1962) produced about 15.5 million board feet.

By 1964, the age and canopy structure of nearly every forested acre was the result of one or more harvest entries, in addition to early, post-settlement wildfires. At this time, about 90 percent of the forest was less than 70 years old. As a result, during the next 20 years, much of the timber harvest was pulp and firewood (Table 3). Timber harvest during the last 30 years has been managed at a relatively consistent level of disturbance, affecting an annual average of 2,000 to 3,000 acres, with partial cuts (thinning, selection, overstory removal) constituting 90 percent or more of the acreage and some form of regeneration harvesting occurring on the remainder.

Starting in 1995, the primary harvesting regime at Fort Lewis shifted to variable-density thinning (VDT). In traditional thinning, as was practiced at Fort Lewis prior to the mid-1990's, the objective is for the post-thinning stand to consist of trees of more uniform size and spacing than before thinning. In VDT, the objective is for the post-thinning stand to be more heterogeneous, in terms of tree size and spacing, than before thinning. VDT is the primary tool for moving conifer stands towards the desired future conditions set forth in the Strategy because it causes gradual increases in horizontal and vertical diversity. In combination with a policy of leaving snags and logs in place, VDT is moving Fort Lewis' forests towards suitable spotted owl habitat.

Overall, Fort Lewis' forests have undergone remarkable recovery since the early days of clearcutting and widespread fire (Figure 5).

Figure 4

Time series of Aerial Photographs of a Portion of Fort Lewis, Showing Invasion of Prairie by Conifer Forest

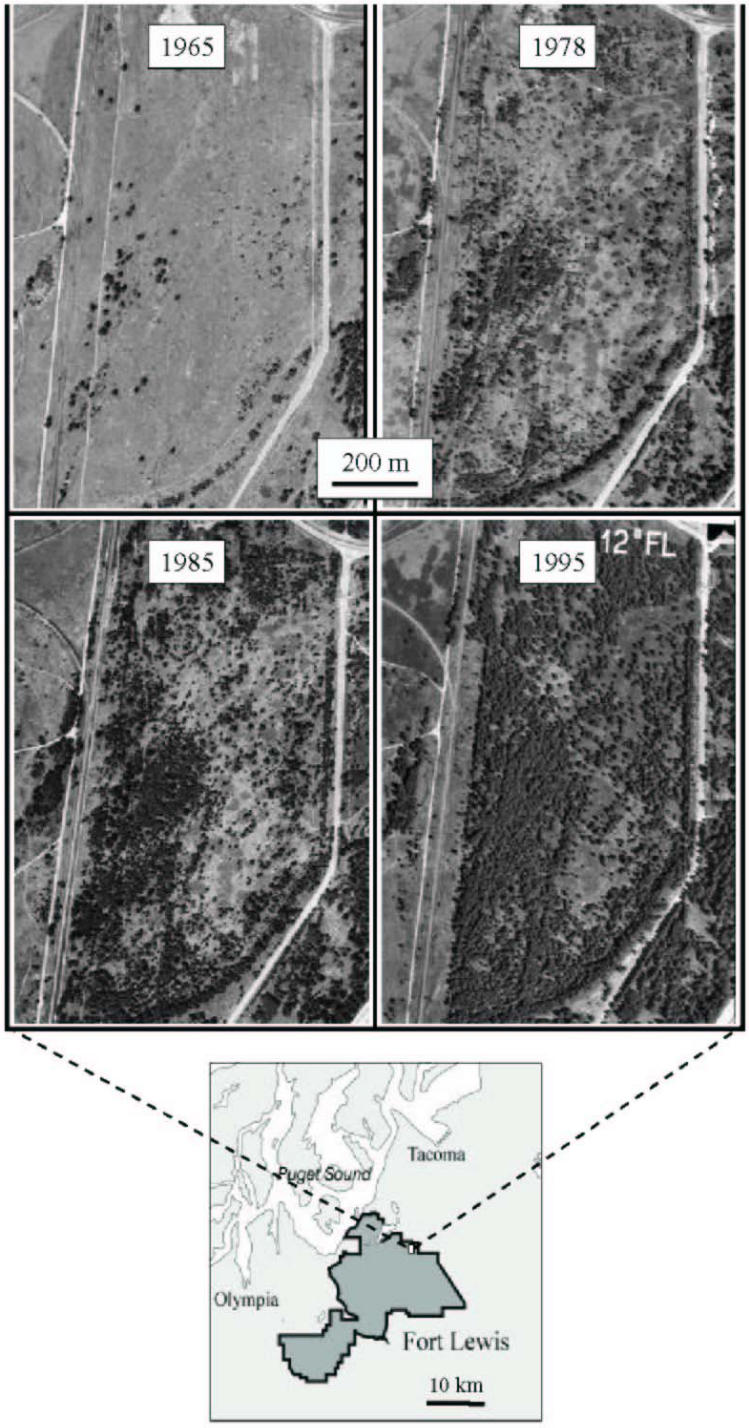


Table 3
Average Annual Harvest of Forest Products from Fort Lewis since 1948

Decade	Sawtimber (mbf)	Pulp (cds)	Firewood (cds)	Poles (cds)	Floral Greens (lbs)
1948-1953	20,167	0	0	0	0
1954-1963	2,688	0	0	0	0
1964-1973	11,086	7,857	303	0	0
1974-1983	12,503	6,045	4,584	30	52,088
1984-1993	10,342	269	2,907	3	159,740
1994-2000	7,397	929	1,750		29,800[1]

Source: Annual harvest records, on file with PW Forestry Program. [1]Harvest discontinued after 1997.

Past Harvest Regulation

In the early 1960's, regulation of harvest at Fort Lewis was modeled after U.S. Forest Service methods (U.S. Army 1976), as follows:

- A 90-year rotation, allowing 10 years for stand establishment, with regeneration harvesting at stand age 80, based on the average age of culmination of mean annual increment .
- Even-aged management with intermediate harvests, shelterwood regeneration cutting, and complete removal of the residual overstory after regeneration is achieved.
- An estimated empirical yield of 15,643 board feet per acre at stand age 80 years.
- A commercial forest area of 45,580 acres available for management.

Calculations based on this early Forest Service model yielded a theoretical annual allowable cut of 8.6 million board feet from about 3,000 acres per year, including 500 acres per year of regeneration harvesting. Occasional harvests from the cantonment and impact areas occurred, in addition to the regulated harvest.

During the 1980s, the approach to determining allowable harvest changed to an area-based estimate with acreages and yields per acre estimated from past performance, as follows:

- About 31,000 acres of managed stands of commercial size, plus 12,000 acres of precommercial stands.
- A 10-year harvest return interval on average, yielding a theoretical area of 3,100 acres per year receiving with some kind of harvest. This theoretical acreage was adjusted to about 2,400 acres based on actual acreages cut in the past (of the stands that come due for a 10-year entry, some stands are not thinned due to low stocking or slow recovery from past thinning).
- About 200 acres per year harvested with regeneration cutting (average yield of 10,000 board feet/acre) and 2,200 acres per year thinned (average yield 3,000 board feet/acre).

The regulated harvest based on this strategy was about 8.9 million board feet per year, with some additional unregulated volume expected from forests in the cantonment and impact areas, and from firewood sales and military cutting of posts and poles.

During the past three years, 54% of timber harvest volume was VDT (Table 4). Combination cuts involve both VDT and partial overstory removal in the same stand. There has been no clearcutting since 1991; the most aggressive timber harvests have been partial overstory removals. The average residual stand diameter in recent years has averaged about 24 inches; the diameter of the cut trees has averaged 18 inches.

Figure 5
Rainier Training Area of Fort Lewis: 1950's (top) and 1990's (bottom)

Table 4
Acreage and Volume of Timber Sales from Fort Lewis
by Silvicultural Practice for Fiscal Years 1998-2000

	Acreage			Volume (thousand board feet)		
Harvest Type	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**
Variable-Density Thinning	801	1,345	1,513	2,855	5,211	5,335
Combination	592	373	249	1,773	1,459	1,081
Partial Overstory Removal	444	257	252	[1]4,170	1,490	1,447
Total[2]	1,837	1,975	2,014	8,799	8,160	7,863

Source: Preview of Timber Sales: FY98, FY99, FY00, on file with PW Forestry Program. [1]Includes 3,621 (mbf) of alder from one hardwood conversion sale. [2]Totals don't match harvest by year (Table 3) because all sales are not completed in the scheduled year.

3. CULTURAL AND HISTORIC RESOURCES IN THE FOREST

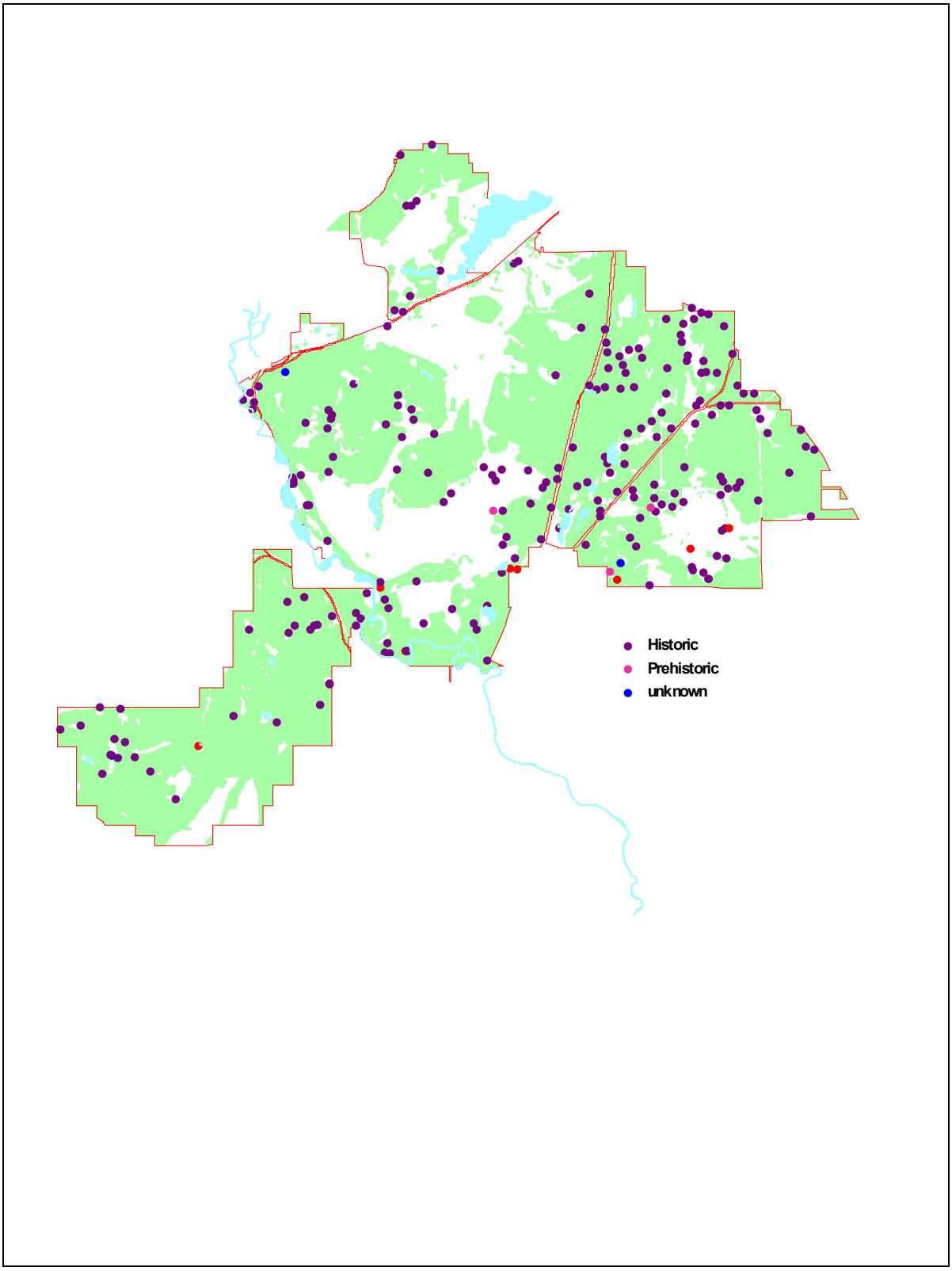
In 1998, the Cultural Resources Management Program at Fort Lewis completed the final phase of an installation-wide survey for cultural resources. Currently, there are 242 recorded archaeological sites on the installation. The majority of these sites are located outside the cantonment area in forested areas and forest/prairie ecotones (Figure 6). Only five percent of the recorded sites are considered prehistoric (i.e., Native American sites which predate 1832, the beginning of sustained Euro-American contact in the Fort Lewis area). The vast majority of known cultural resources on Fort Lewis are pioneer homesteads and farmsteads that date from the 1850s.

During the prehistoric period, Native Americans preferred prairie/forest ecotones adjacent to a reliable water source because plant species diversity was greatest at the prairie/forest margin and forest litter provided fuel for hearths and food processing. The pre-settlement margins of prairies may well contain additional hunter-fisher-gatherer camps, hunting sites, and plant-processing sites (Madison et al. 2000).

The earliest homesteaders also tended to settle and develop areas along the prairie/forest ecotones. A majority of 19th century homesteads were constructed at prairie edges because these locations did not require clearing of trees, yet provided a ready source of building material and a fuel source for cooking and heating. Also, the relatively nutrient-rich prairie land was more easily prepared for farming and provided higher yields (Kennedy et al. 1983, Shong et al. 1999, Madison et al. 2000).

In many cases, the current prairie/forest margin does not reflect the location of prehistoric, or even early historic, prairie/forest ecotones. The 19th century General Land Office maps and 1908 Pierce County Tax Assessor's Timber Cruise maps are useful in determining early historic prairie/forest margins. With these and other sources, the Cultural Resources Management Program is undertaking a site relocation and verification project that will further our understanding of prehistoric and historic land-use and settlement patterns on the presently forested lands of Fort Lewis. The Fort Lewis Forestry Program coordihates with the Cultural Resources office to ensure that the recorded archaeological sites are not impacted by timber sales or other forest management activities.

Figure 6
Cultural Resources in the Undeveloped Portions of Fort Lewis



Source: Geographic data on file, ENRD GIS group; Madison et al. (2000).

D. VEGETATION

1. TREE SPECIES AND VEGETATION COVER TYPES

The forests of Fort Lewis are dominated by Douglas-fir, with large areas occupied by nearly pure stands. Douglas-fir comprises about 90 percent of the forest by volume (see Timber Resources, Sec II.G). Other major tree species, in order of abundance, are red alder, black cottonwood, western redcedar, western hemlock, bigleaf maple, ponderosa pine, Oregon white oak, and Oregon ash. Minor tree species include Sitka spruce, Pacific madrone, bitter cherry, Pacific yew, grand fir, and lodgepole pine.

General vegetation cover types mapped at Fort Lewis (Figure 6) show conifer forests dominated by Douglas-fir occupying about 48,000 acres. Of this acreage, 9,600 acres are moist conifer forest dominated by Douglas-fir (Moist Forest), but with a substantial component of western hemlock and western redcedar, especially in the understory. These forests grow on moderately well-drained soils (primarily Group III soils like Tenino and Alderwood; Table 1) formed on glacial moraine and till, and locally on topographically moist sites within drier conifer forests; these areas have generally been forested for thousands of years. The remaining 38,400 acres are dry conifer forest (Dry Forest), typically dominated by Douglas-fir, with little to no hemlock and cedar. These dry forests grow primarily on extremely well-drained soils (primarily Group 1 and II soils like Spanaway and Everett) formed on glacial till and outwash.

Dry Forests are further subdivided into “historical” (Historical Dry Forest) and “prairie colonization” (Colonization Dry Forest) forests. The former (26,100 acres) occupy areas that have generally been forested for thousands of years, primarily Everett soils (Group II) on glacial till. The latter (16,500 acres) occupy areas that were prairie at the time of European settlement in the mid-19th century, primarily Spanaway soils (Group I) on glacial outwash. Ponderosa pine occurs as a codominant across 1,750 acres of Colonization Dry Forest. Of this area, about 500 acres have pine as the major or sole dominant (Foster 1997).

Other major vegetation cover types that have been mapped include prairies (20,400 acres), white oak woodlands (2,700 acres), wetland vegetation (3,500 acres), and moist-site hardwoods (1,900 acres), which are a successional stage of Historical Moist Forests.

Further assessments of the distribution and structural condition of forests across Fort Lewis are discussed under Ecological Landscape Units (Secs. II.H.5 and III.D.1-3).

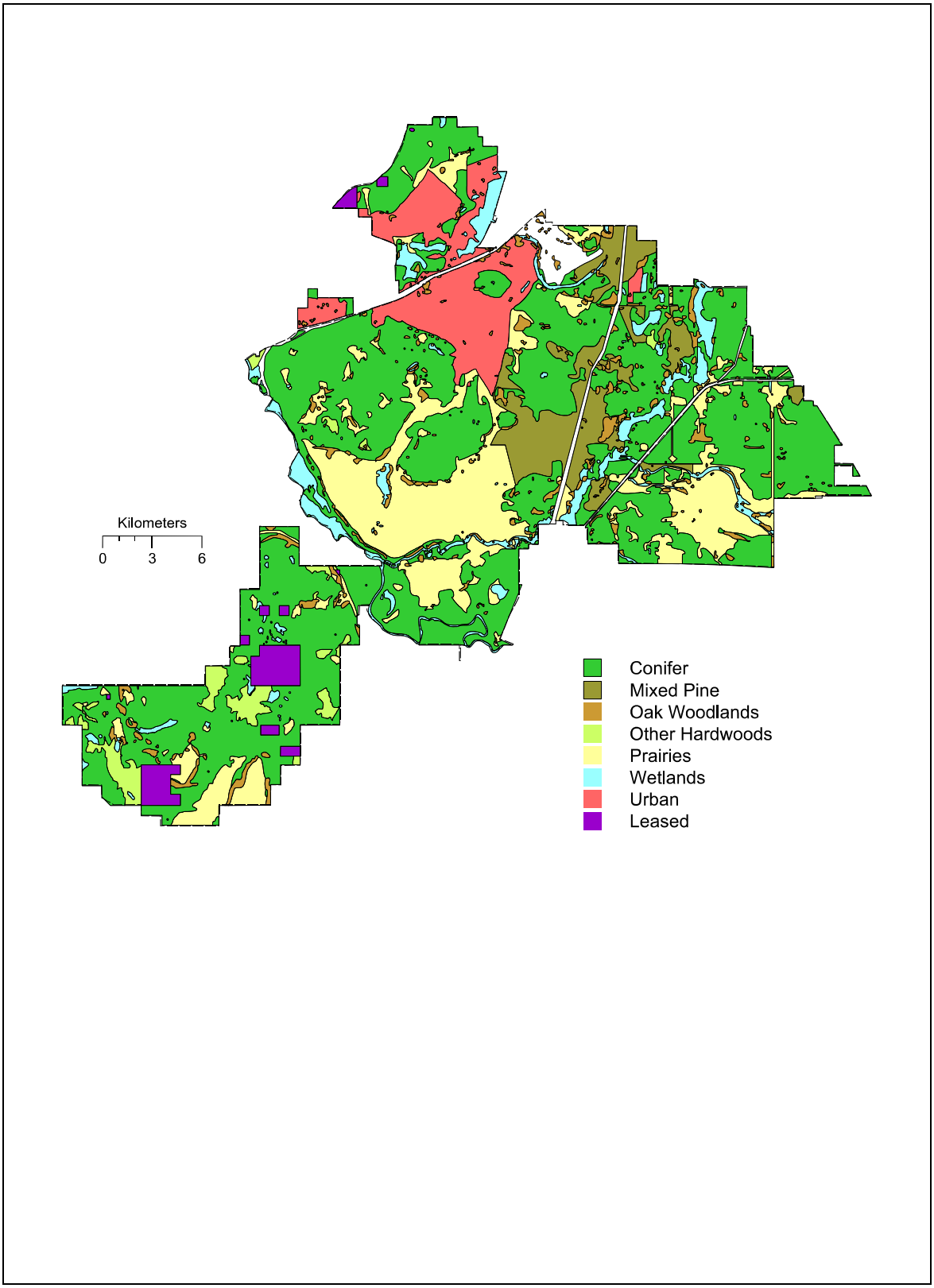
2. PLANT COMMUNITIES

Broad plant community types are most appropriate for assessing both historic and current forest conditions across Fort Lewis. Identification keys for upland plant communities (Chappell 2004) and forested wetlands (Kunze 1994) are available for the Puget Lowlands. These keys permit classification of local forested areas into plant associations (Table 5) on the basis of the abundance of dominant or indicator species. In addition, a predictive map of potential natural vegetation (PNV) across the Fort Lewis landscape has been prepared, using a GIS-based model (Henderson 2001).

Although Fort Lewis is in the Western Hemlock Zone of western Washington (Franklin and Dyrness 1988), the relatively dry climate and predominance of droughty soils at Fort Lewis produce atypical conditions for this zone. Based on old survey notes and current observations of typical species assemblages, much of the historic forest was in drier Douglas-fir types (Douglas-fir Series), characterized by frequent fires and multiple age-classes of Douglas-fir. Most of the extensive forest of Douglas-fir that has arisen on historic prairies and woodlands is also appropriately classified as Douglas-fir Series.

Western redcedar and, to a lesser extent, western hemlock are a significant component of Historical Moist Forests, but their abundance in the overstory is generally low, and on many sites they are found only in the understory. Cedar and hemlock also occur on occasional moist sites in Dry Forests. These sites include glacial depressions and the lower portions of steep slopes,

Figure 7
General Vegetation Cover Types at Fort Lewis



Source: Geographic data on file ENRD GIS group, combines data from Forestry stands database and independent assessments of oak (Kessler 1990, Macklin and Thompson 1992) and pine (Forestry Staff).

Table 5
General Forest Community Types and Forest Plant Associations for Fort Lewis

Community Type	Where Found
Dry Douglas-fir Forests	
PSME/SYMPH-AMAL Douglas-fir/snowberry–serviceberry	Colonization Dry Forests
PSME/COCO–SYMPH/POMU Douglas-fir/beaked hazelnut–snowberry/sword fern	Historical and Colonization Dry Forests
PSME/GASH/POMU Douglas-fir/salal/sword fern	Historical and Colonization Dry Forests
PSME–TSHE/GASH–HODI Douglas-fir–western hemlock/salal–oceanspray	Historical Dry Forests – drier sites
PSME/GASH-HODI Douglas-fir/salal–oceanspray	Historical Dry Forests
PSME–TSHE/GASH–BENE Douglas-fir–western hemlock/salal–Oregongrape	Historical Dry Forests
PSME–TSHE/VAOV Douglas-fir–western hemlock/evergreen huckleberry	Historical Dry Forests
PSME/COCO/POMU–TITR Douglas-fir/beaked hazelnt/sword fern–foamflower	Historical Dry Forests – moister sites
Moist Douglas-fir/Cedar/Hemlock Forests	
PSME–TSHE/GASH/POMU Douglas-fir–western hemlock/salal/sword fern	Historical Moist Forests
PSME–TSHE/BENE–POMU Douglas-fir–western hemlock/dwarf Oregongrape–sword fern	Historical Moist Forests
PSME–TSHE/VAOV/POMU Douglas-fir–western hemlock/evergreen huckleberry/sword fern	Historical Dry Forests
TSHE–PSME/POMU–DREX western hemlock–Douglas-fir/sword fern–spreading woodfern	Historical Moist Forests
THPL–TSHE/OPHO/POMU western redcedar–western hemlock/devil's club/sword fern	Historical Moist Forests – very moist sites
Upland Hardwood Forests	
ALRU/POMU red alder/sword fern	Historical Moist Forests – early-successional
ACMA–ALRU/POMU–TEGR bigleaf maple–red alder/sword fern–fringecup	Historical Moist Forests – steep slopes near saltwater
Madrone Forests	
PSME–ARME/GASH Douglas-fir–madrone/salal	Historical Dry Forests – post-fire succession
PSME–ARME/VAOV Douglas-fir–madrone/evergreen huckleberry	Historical Dry Forests – post-fire succession

Oregon White Oak	
QUGA/FERO Oregon white oak/Roemer's fescue	Historical oak savannas – burned frequently
QUGA/CAIN–CAQU Oregon white oak/long-stolon sedge–camas	Historical oak woodlands and former prairies – burned frequently
QUGA/SYAL/CAIN Oregon white oak/common snowberry/long-stolon sedge	Historical oak woodlands and former prairies – in absence of fire
QUGA–PSME/SYAL/POMU Oregon white oak–Douglas-fir/common snowberry/ sword fern	Historical oak woodlands and former prairies – invaded by Douglas-fir
QUGA–(FRLA)/SYAL Oregon white oak–(Oregon ash)/common snowberry	Historical oak woodlands – riparian zones
Ponderosa Pine	
PIPO/CAIN–FERO ponderosa pine/long-stolon sedge–Roemer's fescue	Historic pine savannas and former prairies – burned frequently
PIPO–PSME ponderosa pine–Douglas-fir	Historical pine savannas and former prairies – invaded by Douglas-fir
Forested Wetlands (including Riparian)	
THPL–TSHE/LYAM western redcedar–western hemlock/skunk cabbage	Saturated soils
FRLA/RUSP Oregon ash /salmonberry	Seasonally flooded
FRLA/CAOB Oregon ash/slough sedge	Seasonally flooded
FRLA/SYAL Oregon ash/common snowberry	Temporarily flooded
POTR–ACMA/EQHY black cottonwood–bigleaf maple/horsetail	Temporarily flooded
POTR–ALRU/RUSP black cottonwood–red alder/salmonberry	Temporarily flooded

Sources: Kunze 1994, Chappell 2004

especially north-facing. Western redcedar was more abundant than hemlock prior to settlement (respectively, ten and two percent by basal area of bearing trees noted in 1853; Appendix C-2), and it is still the most common tolerant conifer on moist sites at Fort Lewis.

The infrequent occurrence of western hemlock at Fort Lewis is unusual compared to similar plant associations found elsewhere in the Puget Trough, Olympic Mountains, and western Cascades. Based on 0.2-acre plot sampling, hemlock is typically present 90 to 100 percent of the time within the Hemlock Series outside of Fort Lewis (unpublished data, Washington DNR Natural Heritage Program, Topik et al. 1986, Henderson et al. 1989). Even within the Douglas-fir Series, small amounts of hemlock occur 20 to 30 percent of the time in typical stands. Hemlock in any amount or canopy position is found only 8 percent of the time in Dry Forests, and only 40 percent of the time in Historical Moist Forests, at Fort Lewis.

The distinction between the Douglas-fir Series and the drier associations in the Hemlock Series is difficult to make under the frequent disturbance cycles (current and historic) at Fort Lewis. Hemlock is often absent from seral stands dominated by Douglas-fir, and the presence of mixed ages of Douglas-fir in the canopy and understory is encouraged by partial harvesting practices, so it does not necessarily indicate "climax" Douglas-fir. In the absence of frequent fires, some

apparently dry communities may succeed towards moister types. This is indicated to some extent by the relatively high productivity of Dry- Forests at Fort Lewis. The average site-index of Dry Forests at Fort Lewis is 109 feet (Ahrens 1998b; using a 50-year base, King 1966), while typical values for the Douglas-fir Series elsewhere in Washington range from 70 to 100 feet (Topik et al. 1986, Henderson et al. 1989).

Thus, vegetation composition and community types should be interpreted with an understanding of the current disturbance regime and categorization of the site within historic forest, woodland, or prairie types. Most historic forests at Fort Lewis were subject to relatively frequent fire, and, more recently, harvesting and military training. Colonization Dry Forests have been subject to repeated thinning and military training. For practical purposes, predominant disturbance regimes are incorporated as attributes of community types, as is developed further under ecosystems (Secs. II.H.4 and III.C).

3. SPECIAL FOREST PLANT ASSOCIATIONS

A number of forested plant associations known or thought to be on Fort Lewis are considered to be of special ecological value due to their limited distribution and biological significance at a regional scale. The Washington Natural Heritage Program (1994) has classified these associations and protection. For example, Priority 1 associations are threatened with destruction, occur over a prioritized their conservation needs according to rarity, existing threats, and current levels of limited range and currently have little, or no, representation in protected areas. Priority 3 associations, meanwhile, are not in immediate jeopardy but still represent significant components of the state's natural heritage. The following forested associations are found on Fort Lewis (Natural Heritage Program priorities in parentheses):

- Ponderosa pine forest (1)
- Western hemlock–western redcedar/skunkcabbage community (1)
- Douglas-fir/snowberry–oceanspray community (1)
- Douglas-fir–western hemlock/Oregongrape community (1)
- Douglas-fir–Pacific madrone/salal community (1)
- Black cottonwood–willow community (2)
- Oregon oak woodland (3)

The location and extent of some of these plant communities have been mapped on Fort Lewis (Kessler 1990, Macklin and Thompson 1992, The Nature Conservancy 1994, Foster 1997). Continued surveys in the future, however, will be needed to better understand the overall distribution and ecological quality of special forest plant associations.

4. THREATENED OR ENDANGERED PLANT SPECIES

Several rare plant species have recently been identified on Fort Lewis in wetland, prairie, and forested habitats. Although some of the species mentioned below are not typically restricted to forested habitats, forest management planning should consider any possible direct or indirect impacts to these species.

Water howellia (*Howellia aquatilis*), a federally threatened and state endangered species, occurs along the margins of seasonally flooded wetlands, typically under a deciduous tree canopies (Lesica 1992). There are 18 wetlands on Fort Lewis that have been found to contain populations of water howellia during surveys for this species (Lombardi 2000). Definition of potential habitat, a list of sites containing potential habitat, and locations of known populations of water howellia are contained in the Endangered Species Management Plan for water howellia at Fort Lewis (Gamon 1998).

A previous study (Lesica 1992) concluded that water howellia is susceptible to disturbances from nearby timber harvests and this should be taken into account in areas where this species is

present. There are 29 timber stands that lie within areas of influence for wetlands containing these populations. An area of influence is defined as that portion of the landscape which serves as the drainage basin for a particular wetland. Forest management activities within howellia areas of influence or in potential habitat will be analyzed for possible adverse impacts in terms of erosion, alteration of microclimate, and changes in wetland vegetation composition. Forest management actions identified as having adverse impacts to water howellia populations or potential habitat will not take place.

Rare plant inventories on adjacent McChord Air Force Base in 1994 also discovered a small population of Torrey's peavine (*Lathyrus torreyi*), a species previously thought to be extinct or extirpated within Washington state (Washington Natural Heritage Program 1994). Torrey's peavine was believed to have existed in prairie habitats (Hitchcock et al. 1961); however, the McChord population is in an uneven-aged, dry Douglas-fir forest. Future plant inventories on Fort Lewis should consider this rare species.

The small flowered trillium (*Trillium parviflorum*) is a state sensitive species occurring in moist woodlands, riparian areas, and forest-prairie ecotones. Documented locations of small flowered trillium are scattered throughout wetland fringes and woodlands associated with Muck Creek, at the south edge of Marion Prairie, and north and east of the town of Roy. However, this species is suspected to occur on the base in other similar habitat types. Because it is found in forested habitats, small flowered trillium populations could be affected by forest management. Pinefoot (*Pityopis californica*) grows in one location in the Rainier Training Area.

Other rare plants found on the fort are not expected to occur in forested habitats. The white-topped aster (*Aster curtus*) is a federal species of concern and state sensitive species generally limited to prairie and savanna habitats. Two other state sensitive species, bristly sedge (*Carex comosa*) and green-fruited sedge (*Carex interrupta*), occur infrequently at the margins of marshy areas.

E. FISH AND WILDLIFE

1. GENERAL

A great diversity of wildlife is fully or partially supported by the various habitats maintained at Fort Lewis. The list includes at least 174 species of birds, 57 species of mammals, 17 species of reptiles and amphibians, and 25 species of fish (Bottorff and Swanson 1993).

Prior to the 1990's, fish and wildlife management at Fort Lewis emphasized "featured species," which were mostly highly-valued game species such as deer and grouse. The shift towards more holistic, ecosystem management began with designation of most of Fort Lewis as critical habitat for the northern spotted owl. Ecosystem management is at the heart of the recent revision of the Fort Lewis Fish and Wildlife Management Plan (U.S. Army 1998). Although emphasis is still placed on developing habitat conditions conducive to spotted owls, the habitat needs of all fish and wildlife species on the installation are now considered.

2. THREATENED, ENDANGERED, AND SENSITIVE SPECIES

Of the many wildlife species, there are at least nine resident species with status as species of concern under federal or state law (Appendix F-1). At least 11 other species of concern are not currently known to be resident but are considered in the management of Fort Lewis due to the current or future potential for habitat within the military reserve (Appendix F-2). It is the policy of the Department of the Army to "prescribe procedures to protect and enhance the habitat of endangered, threatened and /or candidate species on Fort Lewis..." (FL Regulation No. 420-5). Thus, the Fish and Wildlife Program continues to monitor existing and potential habitat areas, and prescribe specific treatments or guidelines for forest management activities to enhance habitat for these species of concern, particularly those currently resident.

3. CRITICAL HABITAT FOR NORTHERN SPOTTED OWL

Fort Lewis plays a key role in the federal Recovery Plan for the northern spotted owl (USDA/USDI 1994), since it is the only significant federal ownership in the Western Washington Lowlands province. This province includes both the Puget Trough and the Washington Coast Range provinces delineated by Franklin and Dyrness (1988). The Recovery Plan states that mature forest habitat and northern spotted owls "have been virtually eliminated" from the Western Washington Lowlands Province due to extensive timber harvest on all ownerships.

Thus, all of Fort Lewis was delineated as a Designated Conservation Area (DCA) in the Recovery Plan. The main recovery goal for the DCA is to establish connectivity between owl populations in the Cascade Range and the Olympic Peninsula. Subsequently, the U.S. Fish and Wildlife Service designated 58,000 acres of Fort Lewis as critical habitat for the northern spotted owl (Figure 8). In general, this requires that forest management activities maintain or enhance habitat for the spotted owl, though spotted owls have not been found (Malkin 1999) on Fort Lewis.

The Recovery Plan estimated that the Fort Lewis DCA could potentially support 21 pairs of spotted owls, a figure apparently obtained by dividing 86,000 acres by an estimate of the average home range size of nesting pairs. This figure is not realistic, given that urban and prairie areas take up about 30,000 acres that cannot be forested in the foreseeable future.

More specific objectives and requirements for silvicultural practices were not specified by the Recovery Plan. These appear in the Habitat Management Plan for the Northern Spotted Owl on the Fort Lewis Military Reservation (Bottorff 1994), and are also addressed in Sections III and IV.

F. HUMAN COMMUNITIES ASSOCIATED WITH THE FOREST

1. THE FOREST IN RELATION TO HUMAN COMMUNITIES

The forests at Fort Lewis provide a variety of direct uses and benefits to humans, including military training, recreation, timber, special forest products, and necessary ecological functions. For purposes of assessing the relative impact of Fort Lewis on human communities, the combined areas of Pierce and Thurston Counties are used as a socio-economic Region of Influence or ROI (U.S. Army Corps of Engineers 1994).

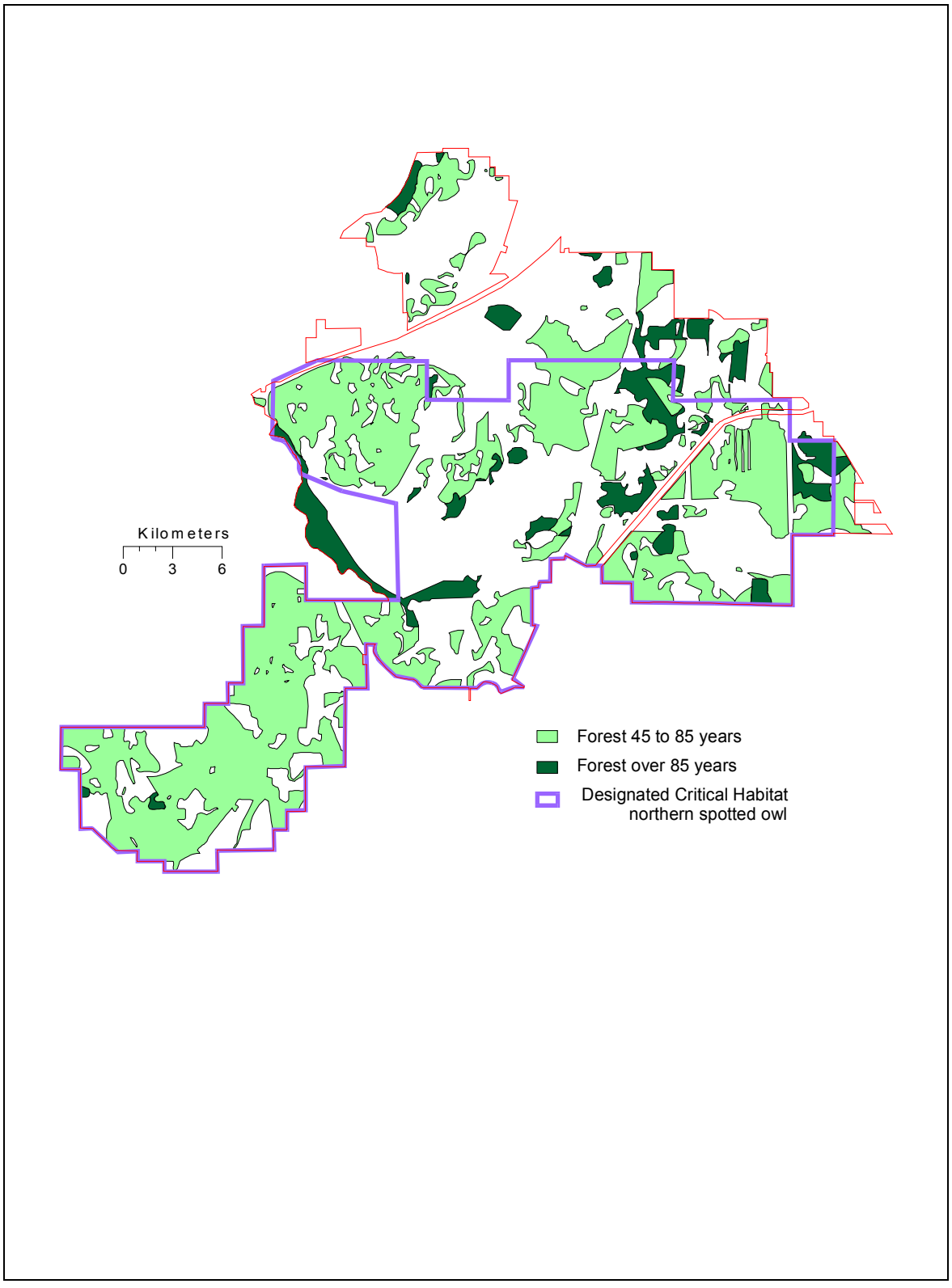
Military

In terms of active human use of the forest, the greatest impact of the forest on humans involves the variety of training exercises occurring throughout the year. Thousands of young men and women from around the nation find challenging habitat and hard work in the Fort Lewis forest each year as part of their military training experience. The varying degrees of concealment offered by individual forest stands provide for a diversity of training conditions. In some stands, timber harvests have been designed to provide specific structures for training (e.g., clearing trees from firing points, landing zones, and primitive airstrips). Military units sometimes harvest pole-sized trees, in coordination with the Forestry Program.

The average military population of Fort Lewis has fluctuated from 15,000 to 25,000 personnel over the last decade (U.S. Army Corps of Engineers 1994). About 20,000 military personnel are expected to be permanently stationed at Fort Lewis during the next five years.

The total, resident population of Fort Lewis (military and family) has fluctuated in recent years, from as high as 26,000 in 1987 to as low as 15,300 in 1991. The 1996-2000 average is 19,700. Another 21,350 soldiers and family members live off post; approximately 95 percent of these live in the ROI (Maris 1991). Approximately 16,000 retired personnel and 4,900 civilian personnel reside in or near the ROI. Altogether, Fort Lewis accounts for about 5 percent of the population of the ROI. In 1997, the military (mostly Fort Lewis, the remainder McChord AFB and Camp Murray National Guard) accounted for 6 percent of total employment in the ROI. Fort Lewis has a large impact on local employment and business, with Fort Lewis expenditures constituting 10 to 12 percent of the ROI's total income (U.S. Army Corps Of Engineers 1994).

Figure 8
Designated Critical Habitat for the Northern Spotted Owl and Forest Age Class at Fort Lewis



Source: Taken directly from FEIS, U.S. Army Corps of Engineers, Seattle District (1994).

Adjacent Communities and Land Use

Development of human communities adjacent to the Fort Lewis Forest is continuing at a rapid pace, increasing the importance of the Fort Lewis forest as an undeveloped area (Figure 9). Members of the surrounding communities make recreational use of various forested areas on the military base for hunting, fishing, hiking, and horseback riding. Recreational and spiritual uses are highly variable and vaguely documented. However, it is important to recognize these as significant uses of forested areas.

The population within the ROI has grown steadily over the years and in 1992 totaled 798,300 persons (U.S. Army Corps Of Engineers 1994). Development north of the installation includes McChord Air Force Base and residential housing interspersed with commercial areas (Figure 8). The areas to the east and southeast of the base are characterized by extensively subdivided, low-density and rural residential development. Land south and southwest of the Fort is comprised of private forest lands and agricultural lands, interspersed with rural residential areas. Rapid development from the communities of Lacey, Olympia, and Tumwater is expanding towards the southwest boundary of the Fort. The Nisqually Indian Reservation and the Nisqually National Wildlife Refuge are adjacent to the western boundary.

Pierce County is the second largest county in Washington in total population. The state Office of Financial Management estimated the 1998 population at 686,800. In the 38-year span from 1960 to 1998, the population of Pierce County increased by 214 percent. It is expected the population of Pierce County will grow at a faster rate in the 1990s than in the preceding decade, which showed an increase of 20.7 percent (Pierce County Planning and Land Services 1993). Even though projections suggest the rate will slow after the year 2000, an estimated 792,179 residents are expected by 2010.

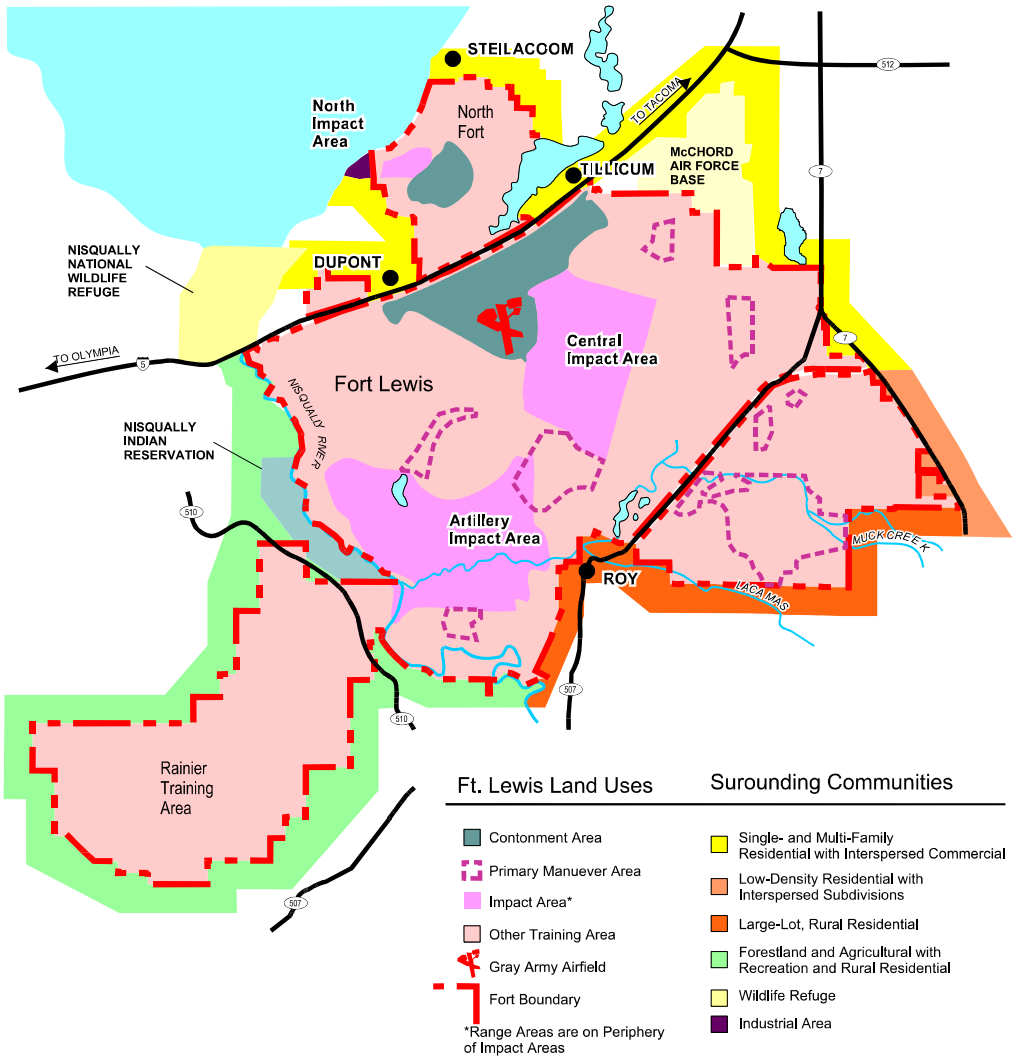
Most of the residents of Pierce County live in the central third of the county along the I-5 corridor, and historically the population has spread from city centers outward to rural areas. In 1920, 23 percent of Pierce County's population lived in unincorporated areas. In 1990, this figure had risen to 57 percent (Pierce County Planning and Land Services 1993). County planners are attempting to decrease the rate of land consumption for sprawling low-density developments, but the rural population is expected to increase from 87,364 in 1990 to 112,931 by 2010.

Thurston County has been among the fastest growing counties in the state and the nation for the past 20 years. In 1998, the total population was estimated at 199,700 residents, an increase of more than 360 percent in 38 years (Thurston County Regional Planning Council 1988 and 1994). The population is projected to increase to 247,000 by the year 2010 (Thurston County Regional Planning Council 1994). The county has experienced a significant increase in the population of unincorporated, rural areas and county planners are exploring methods to concentrate growth in incorporated regions. Projections suggest population in unincorporated regions will increase to 74,389 by the year 2010 (Thurston County Regional Planning Council 1994).

Native Americans

Much of Fort Lewis occupies historic tribal lands and former reservation lands of the Nisqually Tribe. The Nisqually Reservation was established under the terms of the 1854 Medicine Creek Treaty (Kennedy et al. 1983). Two-thirds of the original reservation was acquired by the U.S. Army in 1917 and incorporated into Camp Lewis (Kew 1990). As per the 1854 Treaty of Medicine Creek, the Nisqually Tribe retains and utilizes the right to traditional uses of the former reservation land north of the Nisqually River. These uses include hunting, gathering medicinal and food plants, spiritual activities, and protection of stream corridors for fishing (Carpenter 1994). Members of the tribe operate two fish hatcheries, one on Fort Lewis and one at Klama Creek. Muck Creek and Exeter Springs provide prime spawning ground for chum salmon, and are considered vital habitat for fish populations (Carpenter 1994). A variety of Traditional Cultural Properties of significance to the Nisqually Tribe may occur in installation forests. Fort Lewis is working with the Nisqually Tribe to identify these properties.

Figure 9
General Land Use in Fort Lewis and Surrounding Areas



Source: Taken directly from FEIS, U.S. Army Corps of Engineers, Seattle District (1994).

Forest Products

Timber harvest provides the greatest direct economic contribution from the forests to the local communities. In the time period of 1984-1993, average annual timber harvest from Fort Lewis accounted for about 3 percent of the total harvest within the ROI (Table 6). A rough estimate of the employment provided by timber harvest from Fort Lewis is about 117 direct jobs and 180 indirect jobs (based on average annual harvest of 10.4 million board feet, regional average of 11.25 direct jobs per million board feet and 1.54 indirect jobs per direct forestry job in the Pacific Northwest, (Connaughton et al. 1995). Pierce County makes up 64 percent and Thurston 36 percent of the total timber harvest.

Gathering of "special forest products" has been banned on Fort Lewis since 1998, but substantial, unauthorized harvest is known to occur. The significance of these products is difficult to assess in terms of either commercial or personal values. Inventories are lacking to evaluate the existing crop, and people are resistant to revealing the nature and extent of their gathering. Floral greens such as salal, evergreen huckleberry, ferns, and vine maple are often utilized for decorative purposes (Table 3). Succulent young fronds of fern (fiddleheads) are gathered in early spring. Douglas-fir and grand fir are harvested for Christmas trees and boughs.

Wild mushrooms and truffles are a prized and significant forest product gathered in the ROI, including illegal harvest on Fort Lewis. The most valuable species include chanterelles *Cantharellus cibarius, C. subalbidus*), morels (*Morchella esculenta*), matsutake (*Tricholoma magnivelare*), king bolete (*Boletus edulis*), and Oregon white truffle (*Tuber gubbosum*). All these species are mycorrhizal fungi that form mutualistic associations with living conifer roots. The reported harvest of wild mushrooms in the ROI was 49,917 pounds in 1990 and it is estimated that this represents only 10 to 20 percent of the actual harvest (Molina et al. 1993).

Table 6
Timber Harvest in the Two-County Region of Influence (ROI) Around Fort Lewis, 1984-1993

	Annual Timber Harvest (million board feet)			
	Pierce County	Thurston County	Total ROI	Fort Lewis
Total timber harvest	246.6	139.9	386.5	10.3

Source: Annual timber harvest reports Washington Department of Natural Resources, Land and Water Revenue, and timber harvest reports on file with PW Forestry Program

2. FOREST LAND OWNERSHIP IN THE ROI

The Fort Lewis forest amounts to about 5 percent of the total forest and 10 percent of the federal forest (including National Park) in the ROI (Table 7). There are about 1,115,000 acres of forest in the ROI, comprising 68 percent of the total land area. Ownership of forests within the ROI is 46 percent federal, 44 percent private, and 8 percent state.

3. LAND USE ON FORT LEWIS

Fort Lewis contains three primary, military land-use categories (Figure 10): the cantonment area, training areas, and Gray Army Airfield (Griffin 1993). The cantonment area includes residential, administrative, commercial, industrial, and open space uses. The training areas consist of 75,573 acres, used primarily as maneuver, impact range, and special-use areas (Griffin 1993). Training activities include off-road tracked vehicle movement, wheeled vehicle movement, gunnery practice, digging activities, unit assembly, and unit deployment exercises (Griffin 1993). There are area within scenic or buffer areas, small arms impact areas, leased lands, and conservation reserves,

Table 7
Forest Ownership in the Two-County Region of Influence (ROI) Around Fort Lewis

	Acres		
Forest Ownership	**Pierce County**	**Thurston County**	**Total ROI**
Private forest	328,977	142,643	471,620
State forest	26,437	67,478	93,915
Federal forest (excluding Ft. Lewis)	418,586	78,879	497,465
Fort Lewis forest	**36,500**	**15,500**	**52,000**
Total forest	**810,500**	**304,500**	**1,115,000**
Nonforest	333,500	181,500	515,000
All land	**1,144,000**	**486,000**	**1,630,000**

Source: Pierce County Planning and Land Services 1994, Washington Department of Natural Resources 1994. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Timber Resources Statistics for Western Washington, 1992.

including Research Natural Areas. Non-forested areas of the Fort cover 30,356 acres, including urban areas, grass and brush, artillery impact area (mostly prairie), and open water.

Leased lands are all located in the Rainier Training Area, and belong to Weyerhauser (1,073 acres), Thurston County (331 acres), and the State of Washington (73 acres). Under the lease terms, Fort Lewis is allowed to do nondestructive military training on each of these properties.

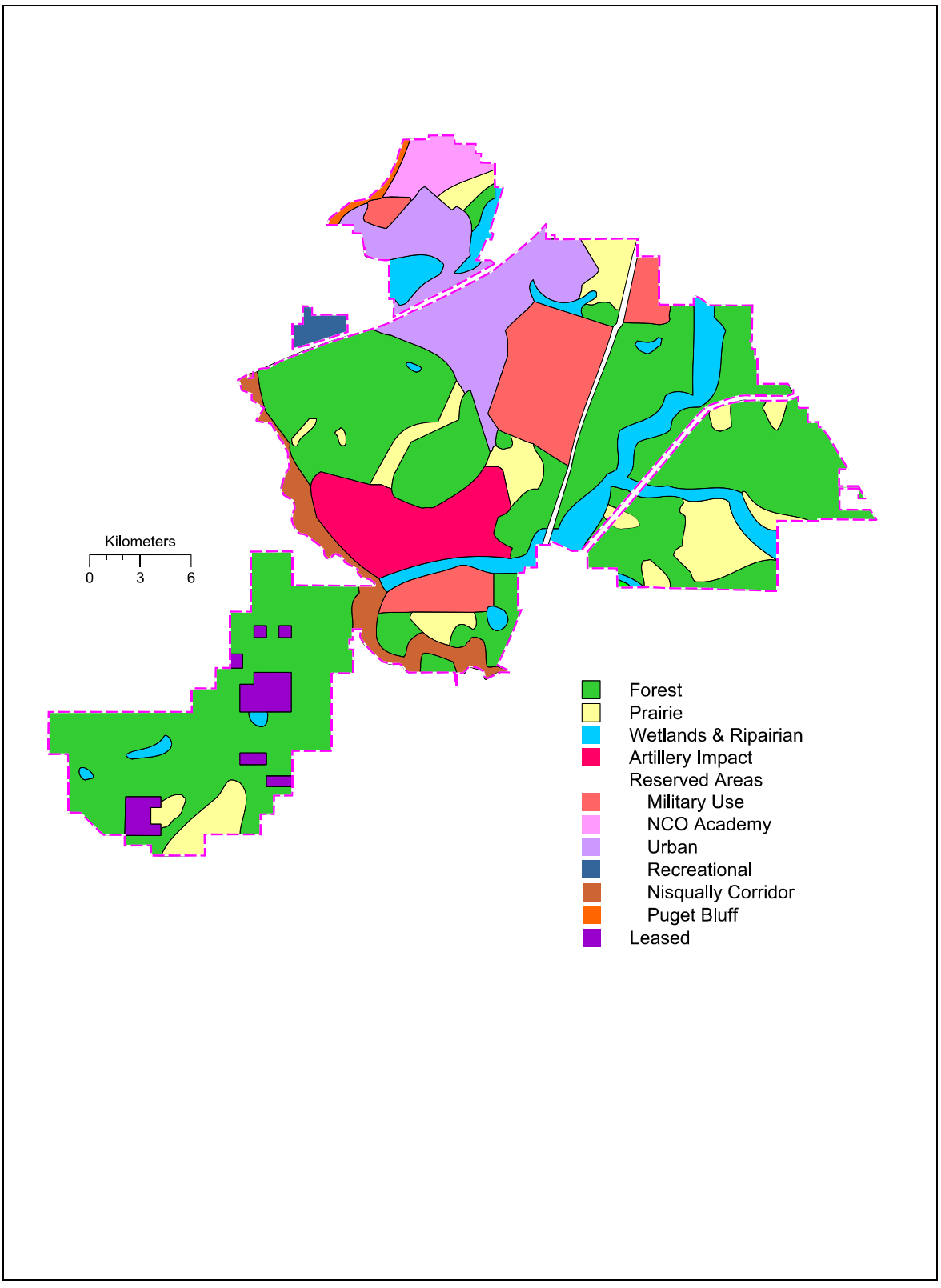
About 38,000 acres of the currently forested area is considered available for unrestricted forest management (Figure 10, Table 8). Management is restricted or modified on the remaining forest.

Table 8
Land Use Classification of Fort Lewis

Land Classification	Area (acres)
Commercial forest	43,064
Buffer zones	2,807
Off-limits military	5,867
Total Forest	**51,738**
Grass, brush	12,491
Urban: buildings, facilities	8,388
Water, swamp	2,930
Off-limits military	8,535
Total Nonforest	**30,931**
Total Government Ownership	**82,669**
Leased, right-of-way	2,094
Total Fort Lewis	**86,176**

Source: PW Forestry stands database, Management Unit Categories.

Figure 10
Land Use Management Classifications on Fort Lewis



Source: Fort Lewis Forestry Program.

G. TIMBER RESOURCES

1. TIMBER INVENTORIES, PAST AND PRESENT

The Public Forestry Foundation (PFF) conducted a forest inventory on the Fort Lewis Military Reservation as part of the effort to prepare this Forest Management Strategy. The goals of this inventory were to:

- Create a bridge between past and present forest inventory procedures and estimates so that growth and sustainable yield could be evaluated.
- Bolster and verify current inventory estimates and present the results in a manner that describes characteristics of timber in useful management terms.
- Provide recommendations for future inventory needs, particularly in the context of ecosystem management.

Comparison of Past and Present Inventories

A continuous forest inventory (CFI) has been in place on Fort Lewis since 1963. It consists of permanent plots that are periodically reinventoried. Over time, trees die or are harvested, and thus "leave" the plots, and saplings grow large enough to "enter" the plots. From these data, total sawlog volume, growth, and mortality can be calculated for the installation as a whole, and for major species and forest types. Details on plot layout and data calculations are found in the Forest Monitoring Plan (Appendix D).

Early (pre-1979) inventories could be classified only into broad forest types (Douglas-fir, other conifer, hardwoods; Table 9). Later, classification of Fort Lewis into Management Unit Categories (MUC's; Appendix G) by the Forestry Program permitted subsequent inventories to be broken down into the following age-class/timber types:

Conifer precommercial: Stands occupied primarily by precommercial conifer trees < 6 inches dbh; includes regenerating shelterwood stands. Combines MUC's 2,3,7,8,9.

Conifer young: Stands dominated by conifers < 45 years old of commercial size. MUC's 4,5,6.

Conifer medium: Stands dominated by conifers 45 to 65 years. MUC's 14,15,16.

Conifer old: Stands dominated by conifers > 65 years of age. MUC's 24,25,26.

Hardwoods: Stands dominated by moist-site hardwoods (red alder, bigleaf maple, black Cottonwood). MUC's 53,55,57,59

Impact area: Forested areas within the Central Impact Area, North Impact Area, and South Impact area. MUC 73

Buffer: Forested scenic and military buffers. MUC's 71,72

Grass & Brush: Non-stocked areas of grass and brush on lands designated as forest land. MUC 1.

The first comparison of total volume (Inventory 1; Table 9) covers the longest time period for which data are available (1963-1993). It is based on the original permanent plot inventory established in 1963, and calculates timber volumes with local volume equations developed for Fort Lewis. The second comparison (Inventory 2; Table 10) covers the period 1979 to 1993. It is based on new inventory procedures initiated by the Fort Lewis Forestry staff in 1979, and calculates volumes using the Washington State Department of Natural Resources' Caltar and Targrade programs, which utilize a combination of average species tarif numbers and species-specific regressions on DBH and height (Chambers 1994). This inventory added plots in the forested impact areas, but to facilitate comparison with Inventory 1, the same total land base (about 47,000 acres) was used to calculate total volume in both inventories. Inventory 3 covers the period 1985 to 1999. The

Forestry Program calculated volumes using OmniTally software, which is based on average tarif numbers for each species based on CFI and timber cruise data. Volumes in this inventory were calculated for the entire installation (86,200 acres), including forested impact areas, with plots in non-forested areas, such as prairies, included as zero values.

Table 9
Fort Lewis Timber Volumes Estimated from Permanent Plots (Inventory 1)

	Total Timber Volume (million board feet)[1]		
Species	**1963**	**1973**	**1993**
Douglas-fir	387	477	897
Other Conifer	14	20	37
Hardwood	25	29	50
All types	426	526	984

Source: Tree volumes were calculated from dbh using local (Fort Lewis) volume equations for each species (U.S. Army 1976). Total volumes are based on a forested acreage of 49,945 acres, which includes forested buffer areas and excludes the forested impact areas. Total plots = 107. [1]Net Scribner scale, 32-foot logs, minimum 6-inch top diameter, species = Douglas-fir, western hemlock, western redcedar, ponderosa pine, red alder, black cottonwood.

Table 10
Fort Lewis Timber Volume Estimated from Permanent Plots (Inventory 2)

	Total Timber Volume (million board feet)[2]	
Age-Class/Timber Type	**1979**	**1993**
Conifer precommercial	30	15
Conifer young	100	15
Conifer medium	290	441
Conifer old	103	387
Hardwood	46	45
Forested buffer area	47	100
Grass & Brush	2	1
Total (acres)[3]	618 (46,482)	1,004 (46,567)

Source: Tree volumes were calculated using tarif volume equations (Chambers 1994, Bracket 1973). Number of plots=124, with additional variable radius plots (n = 500) to better represent age-class/timber types. [1]Net Scribner scale; same species as Table 9. [2]Acreage of buffer areas changed between 1979 and 1993. Acreage was determined from mapped acreages of all Fort Lewis stands, categorized by age/class and type, DEH Forestry Stands Database.

Figure 11 shows the increase in total standing timber volume (sawlog only) estimated by the three methods. Despite differences in numbers of plots sampled, the first two inventory methods yield remarkably similar estimates of total volume for the installation during the period of overlap (1979-1993). However, Inventory 3 shows substantially higher volumes than the other two methods. For example, the 1993 volumes were 980 (Inventory 1) vs. 1,000 (Inventory 2) vs. 1,276 (Inventory 3) million board feet. Part of this difference is attributable to the different acreages used for calculation. When PFF repeated the 1993 analysis using total forested acreage (52,250), the volume estimate increased to 1,115 million board feet (Figure 11; Table 12). In that same year, PFF included additional subplots in the sampling of each plot, thus increasing both the area sampled per plot and the number of trees per plot. When the PFF analysis was repeated again by Fort Lewis Forestry, excluding the subplots and using all forested acres, the resulting estimate of total volume increased to 1,390 million board feet (Figure 11). It appears that, by chance, the subplots had lower average volume/acre than the core plots alone, accounting for the lower total volume in the original PFF analysis. The difference between 1,390 and 1,276 may be attributable to (1) the two inventories' different methods of calculating individual tree volumes, and (2) the lack of tarif trees in Inventory 3 (e.g., only 281 Douglas-fir and 10 red alder in 1999).

To provide consistent and repeatable inventories in the coming years, Fort Lewis will adopt a standard protocol for the CFI. No subplots will be used; the comparison of the 1993 CFI with and without subplots showed little difference in SE% (standard error as percent of the mean) for timber volume, by species or by timber type. However, the number of tarif trees sampled will be increased, with extra effort made to measure tarif trees for species other than Douglas-fir. Volumes will be calculated using the Stand Inventory System (SIS) program (Mason, Bruce, and Girard 1997).

Substantial accumulation of standing timber volume is demonstrated by all three inventories. Using data from Inventory 1, net timber volume increased by 558 million board feet (about 130 percent) over the 20-year period, 1974-1993 (Figure 11). This represents an average net annual increase in standing stock of 18.6 million board feet. Accumulated harvests over this same period totaled 350 million board feet (Figure 11), or an annual average of 11.7 million board feet. Since inventory plots are not protected from harvest, these data indicate a total growth increment of 908 million board feet, or 30.3 million board feet per year. Adding mortality, estimated at 120.3 million board feet over the same period (Table 11), or 4.0 million board feet per year, yields an estimate of gross growth of 1,028 million board feet.

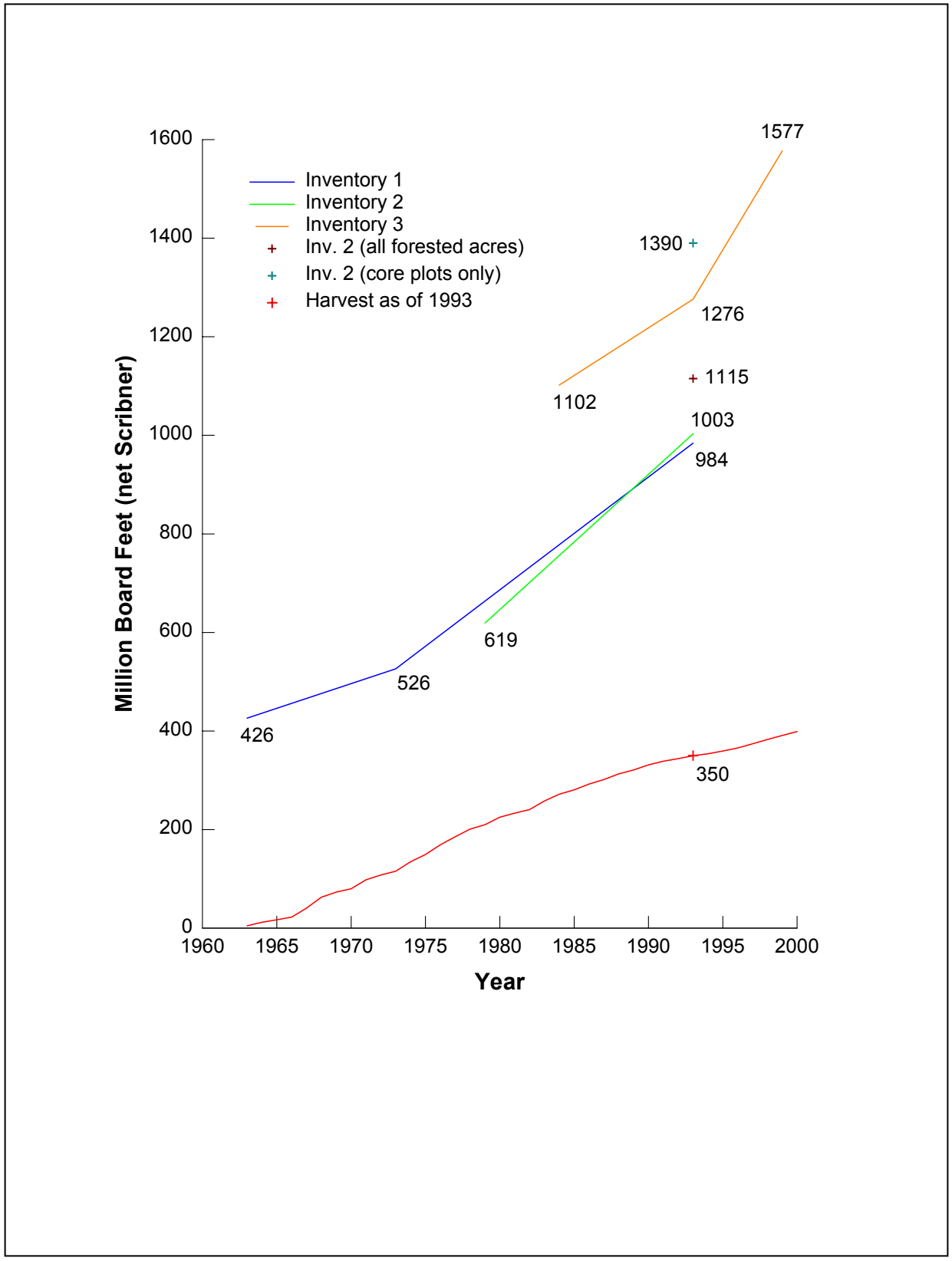
During the most recent inventory period (1985-1993), average annual harvest was lower, annual mortality the same, and annual net growth larger than the 30-year averages (Table 11). Thus, the rate of growth has accelerated. Inventory 3 indicates that total net volume increased at an even more rapid rate between 1994 and 1999 than in the previous 30 years, while harvest was about the same (Figure 9).

Note that an estimated sawtimber harvest of 6.4 million board feet per year was calculated based on trees removed from remeasured plots between 1985 and 1993. This is less than the actual harvest figure of 8.6 MMBF (Table 11), an indication that harvested volume may be under-represented by about 25 percent on the plots.

The results from Inventory 2 are expanded in Tables 12-14 to characterize the forest inventory as of 1993. This analysis could not be repeated for 1999 because of the lack of tarif trees, and the above-mentioned differences in inventory methods.

The 1993 net volume of the entire Fort Lewis installation was **1.12 billion board feet**, an amount that has increased substantially in the past seven years (Figure 9). Volume per acre was very similar between the medium and old conifer types. This was probably due to the fact that thinning regimes maintained similar stocking levels in the two types; indeed, stands in the older age class had more thinnings and lower average basal areas. Also, the average age of the medium age-class was 59 years, which is close to the upper boundary of the age-class range. In combination, the medium and old conifer types contained 77 percent of the total net timber volume and occupied 62 percent of the forested acres. The statistical precision of the total volume estimate was relatively good, with SE% = 5 (Table 12).

Figure 11
Historical Changes in Timber Volume at Fort Lewis



Source: As in Tables 9 and 10.

Table 11
Timber Harvest, Mortality, and Growth at Fort Lewis from 1963 to 2000

	Average Annual Volume (million board feet)[1]		
	1964-1973	**1974-1984**	**1985-1993**
Harvest (scaled)	11.1	13.8	8.6
Mortality	1.5	6.3	4.0
Net Growth	10.0	24.9	25.6

Source: Mortality is estimated from trees dying on remeasured permanent plots. Growth is estimated from the net change in total volume estimates from both remeasured plots and supplemental plots when available. [1]Net Scribner scale; same species as Table 9.

Table 12
Acreage, Net Volume per Acre, Total Net Volume, and Average Defect by Age-Class/Timber Types in Fort Lewis Forests, 1993

Age-Class/Type	Acres	Volume/Acre (board feet)[1]	S.E.%[2]	Defect (%)
Conifer precommercial	9,345	1,660	27	7.0
Conifer young	1,269	11,698	22	1.5
Conifer medium	16,062	27,480	7	1.6
Conifer old	14,882	26,002	6	3.6
Hardwood	1,980	22,832	19	1.7
Forested buffer area	4,271	23,505	14	6.0
Forested impact area	4,441	26,535	28	6.1
Non-forested area	33,950			
Total Fort Lewis	**52,250**	**21,436**	**5**	**3.2**

Source: Acreage from Forestry Stands database. [1]Volume (sawlog) estimated from 1999 measurements on permanent sample plots, using average tarif numbers. [2]Standard error as percent of the mean.

Douglas-fir is by far the most abundant species among Fort Lewis' forest trees; as of 1993, 90 percent of the total net volume was Douglas-fir (Table 13). The next most abundant species, red alder comprised only about 3.4 percent of the volume. Western redcedar was the most abundant conifer after Douglas-fir, comprising 1.7 percent of the total volume. Note that the estimates for minor species are imprecise, due to their absence from most plots and thus their high SE%'s. The statistical precision of the estimate of Douglas-fir volume was relatively high, with SE% = 5.

Douglas-fir site index (50-year base, King 1966) averages 112 feet (Table 14; Ahrens 1998a), which places the productivity class in the high end of Site Class III. Over the 13-year period, 1985-1993, the average stand age (weighted by stand acreage) increased from 53 to 64 years. Thus, in spite of harvesting on 2,000-3,000 acres each year, the forest continues to age, since the majority of harvesting treatments are thinnings, which do not regenerate new stands or decrease average

stand age. The average 1993 tarif number of 33.8 was comparable to the 1979 average of 33.1 (tarif is calculated from diameter and height of sample trees and is used to estimate volume).

Table 13
Total Net Volume, by Species, at Fort Lewis in 1993

Species	Total Net Volume (million board feet)[1]	SE%[2]
Douglas-fir	1,001	5
red alder	38	27
black cottonwood	20	53
western redcedar	17	33
western hemlock	13	58
bigleaf maple	11	37
ponderosa pine	8	55
Oregon white oak	3	35
Oregon ash	2	86
Sitka spruce	2	100

Source: Forestry Program. [1]Volume (sawlog) estimated from measurements on permanent inventory plots.
[2]Standard error as percent of the mean

Table 14
Mean Stand Age, Douglas-fir Site Index, Basal Area per Acre, Mean Stem Diameter, and Tarif Number by Age-Class/Type at Fort Lewis, 1993

Age-class/type	Age (yrs)	SI 50[1] (ft)	Basal Area (sqft/acre)	Mean DBH (inches)	Ave. Tarif (Doug-fir)
Conifer precommercial	14	104	26	13.9	22.8
Conifer young	43	105	110	11.3	28.4
Conifer medium	59	118	160	16.0	36.4
Conifer old	82	110	144	20.6	36.9
Hardwood	55	125	157	14.5	35.4
Forested buffer area	105	115	151	16.4	37.1
Forested impact area	77	104	147	17.5	36.0
Average all types (weighted by acreage)	**64**	**112**	**128**	**16.9**	**33.8**

[1]Height at 50 years age (King 1966).

2. PRODUCTIVITY AND SUSTAINABLE TIMBER YIELD

Several key points should be noted in light of the substantial net increases in volume revealed by the 1993 timber inventory. First, the 1960's estimates of empirical yield (15,643 board feet/acre at age 80) and mean annual increment (196 board feet/acre/year) are quite low. A much higher level of productivity is indicated by current measurements of both empirical yield and potential productivity, based on site index.

Second, the 1993 estimates of empirical yield show standing volumes averaging 27,480 board feet/acre at an average age of 59 in stands that have, in most cases, been thinned once (Table 12). An average volume of 26,000 board feet/acre was found for older stands (average 82 years) that have been thinned twice on average. Including estimates of thinning volumes (3,000 board feet/acre per entry), current data indicate mean annual increment in the range of 400 to 500 board feet/acre/year. With the current managed area of 46,180 acres, this could provide a maximum sustained yield of 18 to 23 million board feet per year. Current estimates of site index (Table 14) indicate an even higher level of potential productivity.

Obviously, the recent estimated net growth of 25.6 million board feet per year, when compared to the recent annual harvest level of 8.6 million board feet, also indicates that harvest is well below the sustainable yield possible if the forest were managed primarily for timber production. Note that the rate of growth during 1985-1993 was higher than the long-term sustained yield because it represented a period of rapid volume growth (average age of forest increased from 53 to 64 years).

H. INTEGRATING COMPONENTS: ECOSYSTEMS

1. ECOSYSTEM INVENTORY AND ASSESSMENT

The first step in developing an ecosystem management approach is to describe and assess ecosystems on Fort Lewis. Current information on ecosystem attributes is limited to a wide variety of independent inventories or studies; detailed information is lacking for many resources or ecosystem levels at Fort Lewis. New inventories are ongoing, however, and an integrated information system has been developed at Fort Lewis (ENRD GIS group). A preliminary description of Fort Lewis ecosystems is given below, along with priorities and recommendations for refinement based on the more detailed and precise information that will be available in the future.

2. FRAMEWORK FOR DESCRIBING ECOSYSTEMS

Ecosystem assessment is based on a logical, hierarchical framework for viewing complex patterns and processes at different landscape scales and ecological levels of organization. A practical framework for Fort Lewis is built as follows: Historical and present ecosystem conditions are assessed and ecosystem management strategies are developed for broad vegetation community types and Ecological Landscape Units (ELU's). These two organizational levels encompass appropriate scales for the majority of ecosystem components at Fort Lewis, based on the relatively coarse level of existing ecosystem inventory.

Vegetation community types provide the primary level for characterization of disturbance regimes, species composition, stand structure, successional stages, and local ecological stability. ELU's are designated for control of landscape-level attributes and patterns such as stand age-class diversity, patch-size, community type composition, landscape stability, spatial patterns of connectivity, and functional interaction between types.

Landscape subunits may also be needed, depending on landscape features within ELU's, such as isolated forested areas, special military training areas, and barriers or links between ecosystems. While these subunits can be defined in a preliminary way based on geographic and topoedaphic features, complete incorporation and assessment of subunit attributes into the ecosystem framework will depend on stand-by-stand and larger-scale information from current inventories.

3. HISTORICAL ECOSYSTEMS AND PROCESSES: "PROVEN MODELS"

Historical ecosystems and ranges of variation provide the basis for understanding potential Fort Lewis ecosystems under a given disturbance regime. Given our incomplete understanding of ecosystems and their functions, formulation of ecosystem management strategies often uses natural ecosystems and disturbance regimes and their historic ranges of variation as "proven" models. Thus, observations and survey notes from the Fort Lewis area from the 1850's were studied in order to make some characterization of historic patterns of vegetation, vegetation dynamics, and disturbance regimes across the range of physical environments that occur on the installation.

4. DESCRIPTION OF FOREST CONDITIONS BY COMMUNITY TYPES

Current forest cover types on record do not distinguish between Dry and Historical Moist Forests, but the necessary information to reclassify Fort Lewis' forests on this basis is being collected. Estimates of the distribution and condition of both current and historical community types are based on (1) vegetation types and species noted in 1850's survey records, (2) current observations made during remeasurement of permanent inventory plots, and (3) the underlying distribution of topographic and soil conditions.

The post-settlement disturbance regime induced significant changes in the distribution of vegetation types and in the stages of structural development and processes within vegetation types (Table 15). These are discussed below for each community type and landscape unit. Major changes include the widespread development of a Colonization Dry Forest (see Section I.D.1) that occurs on approximately 16,500 acres of historic prairies and woodlands (Figure 12). Thus, in spite of the conversion of 8,000 acres to urban or developed uses, there has been a large increase in forested area, with corresponding decreases in oak woodlands and prairie.

Although recent Colonization Dry Forests were stimulated by the post-settlement disturbance pattern, there is certainly a natural precedent for the advance of Douglas-fir at forest/prairie ecotones. Much of the "old" forest has arisen from relatively recent (4,000-6,000 years) succession of Douglas-fir onto grasslands, as is indicated by pollen records.

Dry Douglas-fir Forest

Most of the Fort Lewis Forest is a dry Douglas-fir type (approximately 68 percent). Dominant understory plants include salal, snowberry, oceanspray, hazel, scotch broom, and grasses. The predominance of these relatively dry conditions is due to low annual precipitation and xeric soil moisture regimes typical of the excessively drained Group I and II soils where these forests are found. Vegetation associations similar to those found in Dry Forests at Fort Lewis occur on dry forest sites east of the Olympic Mountains, in the western Cascades, and along the Willamette Valley margin. However, there are no directly comparable analogues for these Puget Lowland Dry Forests in their natural state.

Compared to Moist Forests, Dry Forests have about 35% lower annual aboveground net primary productivity and 15% lower annual wood production. However, Fort Lewis' Dry Forests are more productive than Dry Forests in the Washington Cascades and Olympics, and have similar productivity to Dry Forests in the Oregon Cascades and Willamette Valley. In the Pacific Northwest, leaf area index of mature Dry Forests is 4-7, compared to 8-12 for Moist Forests (Ahrens 1998b).

Basal area, overstory cover, snag density, and log biomass at Fort Lewis decrease in the order Moist Forest > Historical Dry Forest > Colonization Dry Forest. Site index is slightly less in Dry Forest than in Moist Forest.

Historical forests at Fort Lewis typically occurred on hills of glacial till, dry slope/aspects on moraine hills, and on slopes or channels of outwash terraces. Historical forest sites also occurred as islands of forest surrounded by woodland/prairie. Colonization Dry Forests have arisen in extensive areas on gentle outwash (Group I soils) that were formerly prairie. Colonization Dry Forests have a predominance of grasses in the understory and poorly developed forest attributes, such as understory shrubs and herbs, woody debris, and forest floor humus (Ahrens 1998b).

Table 15
Estimated Distribution of Vegetation Community/Cover Types in 1853 and 1993

	Percent of total area	
Community Type	**1853**	**1993**
Moist Douglas-fir	15	15
Dry Douglas-fir	30	40
Pine/Douglas-fir forest	?	2
Wet\floodplain forest	2	2
Subtotal forest	47	59
Oak, oak/fir woodland	6	4
Pine/oak savanna	7	?
Subtotal woodlands	13	4
Prairie	36	24
Urban/developed	0	9
Water	4	3
Unclassed	0.3	1

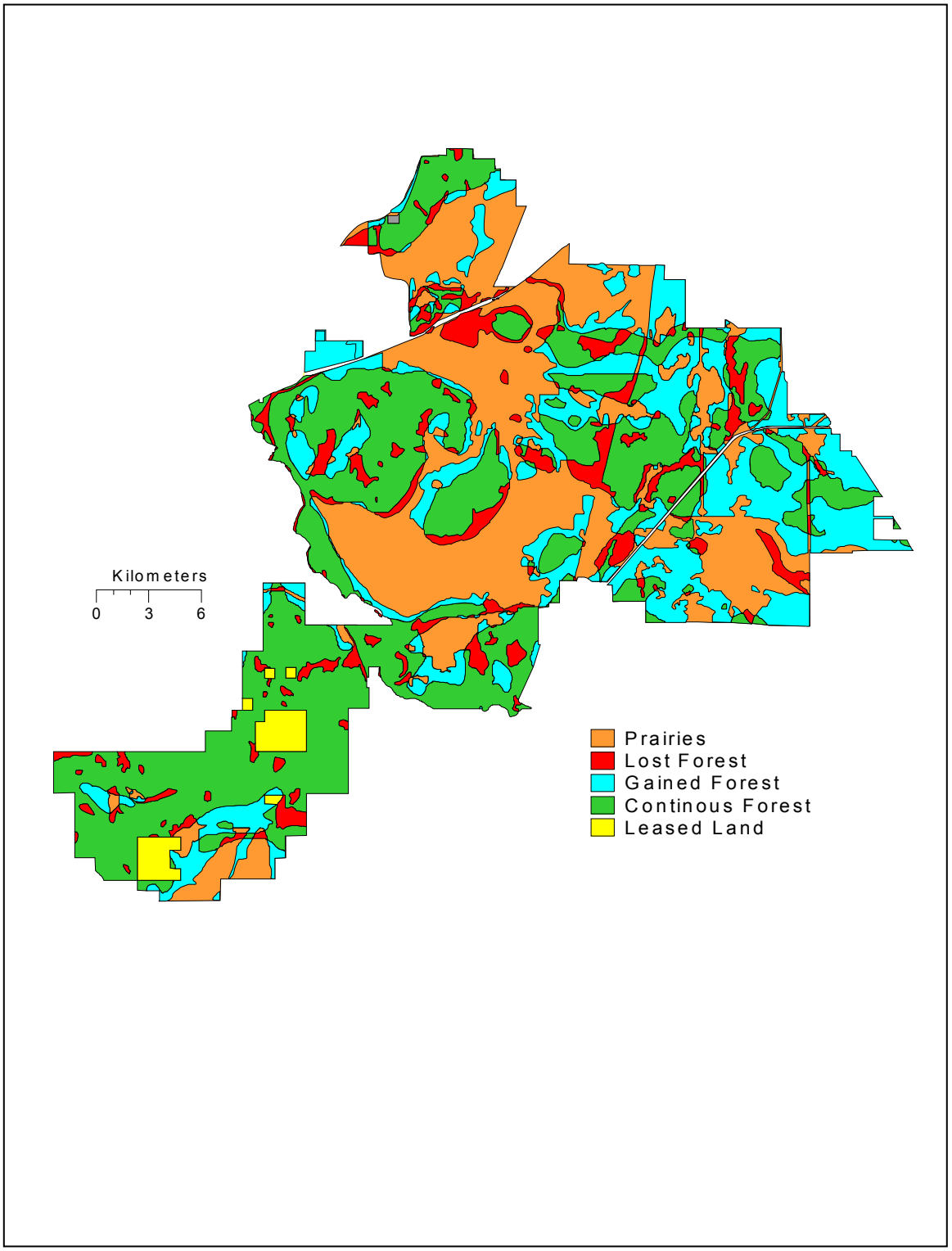
Source: 1853 estimates based on Surveyors notes on general forest types from section lines used as transect samples to calculate percentage of area (Government Land Office 1853, 1871). 1990's estimates from mapped cover types with percentage of various forest types estimated from classification of forest inventory plots. Also based on the following assumptions: (1) area of Historical Moist Forest sites and Wetland/Floodplain Forests has not changed significantly from the 1850's ;(2) colonization Douglas-fir forests are Dry types.

Natural Dry Forests are often maintained by moderately frequent, mortality-inducing fires (25-100 years) of variable and patchy severity (Agee 1991, 1993). At the stand level, such fires cause occasional mortality of medium to large-sized trees. Seedlings and saplings are subject to high rates of mortality. Fuel levels and coarse woody debris are generally low to moderate under this type of fire regime.

The predominance of moist versus dry ecotones bordering Dry Forest sites played a significant role in determining the historical fire regime of Dry Forests at Fort Lewis (see discussion under Ecological Landscape Units). Stands bordered by dry, woodland ecotones probably experienced more frequent light fires that maintained lower fuel levels and caused little or no mortality. At the more moist end of the gradient, and with predominantly moist ecotones within contiguous forest, higher fuel accumulations and less frequent ignitions produced more severe, stand replacement fires (150-250 years). For example, the 1850's survey noted large areas of recently fire-killed timber across both Dry and Moist Forests in areas of contiguous forest with few woodland ecotones (RTA and northwest Argonne Forest). At the same time, very little evidence of severe fire was noted in forest areas in the mosaic of forest, prairie, and woodland on the central and northeastern Fort (Appendix C-1).

Under the variable fire regimes described above, the canopy structure in Dry Forests can range from uneven-aged and patchy to relatively even-aged or two-storied. The overstory may be open or closed, dominated by large fire-resistant trees. A patchy, intermediate canopy is typical, and Douglas-fir is the dominant species in the understory. Douglas-fir seedlings and saplings are few to

Figure 12
Changes in Forest Cover at Fort Lewis Since 1870



Source: 1870's map prepared by the Government Land Office from field original land survey notes (Government Land Office 1853, 1871); current cover types from geographic data on file, ENRD GIS group.

many in patches of varying size, depending on time since fire. Mortality rates are high in small trees, with few surviving to fire-resistant size.

Dry Forests can be relatively stable habitats at the landscape and stand level, as long as the moderately frequent disturbance regime is maintained. At a smaller scale, they are characterized by a shifting pattern of patches on the order of 0.5 to 5 acres in size, with shifting margins at ecotones with woodlands or Historical Moist Forests. Based on the succession to moist-site species (western hemlock, swordfern) observed in some site-specific comparisons between 1853 and 1993, some Dry Forest sites will succeed towards a more Moist Forest condition with longer intervals between disturbance.

Current Conditions in Dry Forests Relative to Historic Conditions

Compared to the historic fire regime, current disturbance processes are characterized by reduced variability in the intensity and frequency of fire; low fuel levels have been maintained to some extent by harvesting. Soil disturbance was negligible under the historic fire disturbance regime. Variable levels of soil disturbance now coincide with canopy openings caused by harvesting.

The species composition of vegetation during recovery after historic fire was probably a rearrangement of pre-disturbance shrub components, with increases in native grasses and forbs after severe disturbance. Currently, exotic grasses and forbs, and in many cases Scotch broom, increase with moderate to severe disturbances, which generally includes significant soil disturbance from logging and military training.

The recent predominance of dispersed thinnings has maintained relatively uniform disturbance and partial canopy cover in many stands. Understory cover is generally high in the absence of fire, and thinned stands have a particularly well-developed and uniform understory cover of characteristic shrubs and grasses (average understory cover 42 percent). Small scale (30 to 300 ft) patchiness and clumpiness is reduced both in the overstory and understory of thinned stands. However, a significant portion of the stands have multiple age classes and patchier canopy cover (52 percent two-storied or multi-aged), recently encouraged by more diverse cutting practices, especially variable-density thinning.

Older age classes of trees (>100 years) occur in about 25 percent of the current Dry Forest; the frequency of large trees (>36 inches dbh) is about half of that in the historic Dry Forest landscape (Appendix A-6 and D-4). Even with repeated thinning from below, there is a greater relative frequency of smaller, younger trees (<12 inches dbh) with fire suppression in Dry Forests.

Significant snags and dead wood are rare or absent, with an average of only 0.12 large snags per acre and only minor amounts of large woody debris in most stands (Ahrens 1988a, Appendix A-6). Although woody debris in native Dry Forests was relatively low compared to typical Hemlock Zone forests; early logging removed much of the large wood that normally carries over after fires. More recently, mortality-risk harvesting and retention of well-spaced, high-quality trees has maintained low levels of decadent trees in most Dry Forest communities. Colonization Dry Forests, in particular, are deficient in snags, dead wood, and other legacy attributes that develop only after long periods of continuous occupancy by forests (Ahrens 1988b, Appendix A-8).

The root disease, *Phellinus weirii,* is a significant factor affecting the structure and pattern of Dry Forests at Fort Lewis. *Phellinus* is known to occur in at least 20 separate stands, though the incidence of the disease has not been thoroughly mapped. Three out of 59 plots (5 percent) in historic Dry Forest or woodland had major pockets of mortality from *Phellinus*. As yet, *Phellinus* is rare to non-existent in Colonization Dry Forests. *Phellinus* generally causes pockets of mortality from 0.1 to 1 acres in size, though larger areas may be infected with continued spread and aggregation of smaller pockets over time. In the absence of stand reegenerating disturbances, *Phellinus* pockets tend to fill with species that are not susceptible to the disease (brush, white oak, bigleaf maple). The current status of *Phellinus* relative to historic conditions is unknown..

Moist Douglas-fir/Redcedar/Hemlock Forest

Approximately 25 percent of the Fort Lewis Forest is a moist Douglas-fir /redcedar/hemlock type. Douglas-fir is generally dominant in the overstory. Western redcedar and, less commonly, western hemlock occur as codominants, intermediates, and in the understory. Bigleaf maple and Pacific yew are also common as intermediate or understory components. Oregongrape, salal, red huckleberry, trailing blackberry, and swordfern are predominant in the understory. Salmonberry and thimbleberry occur on very moist sites. Drier associations such as western hemlock/salal, may be developing on some historic woodland sites. Following logging or fire, hardwoods, especially red alder, may dominate Moist Forest sites for several decades.

Moist Forests at Fort Lewis north of the RTA are typically distributed as isolated stands or groves in a Dry Forest matrix due to the infrequent occurrence of moist site conditions. The largest contiguous areas of Moist Forest in this region are along the Nisqually River and Muck Creek corridors and on the Puget Sound escarpment. Moist sites are also found on lower slopes and pothole depressions, on the margins of wetland depressions, north slopes on hills of glacial till, and on lower north slopes of outwash terraces and channel breaks. Typical ecotones are wetland or riparian vegetation on the moist margin and Dry Forests on the dry margin. Small groves or strips of Moist Forest may grade into woodlands at abrupt wetland margins. In the RTA, Moist Forest occupies a large block on the old recessional moraine of the last continental glaciation.

Moist Forests in the Western Hemlock Zone are generally subject to infrequent, severe fires (every 200-300 years). At the stand level, such fires cause extensive mortality of medium to large-sized trees. Competition is the dominant process affecting mortality of seedlings and saplings during cycles between fires. Fuels and coarse woody debris accumulate cyclically, with the highest levels occurring in old growth and during the stem exclusion stage in young patches, overlaying residual wood from the previous cycle.

The fire regime of Moist Forests at Fort Lewis, however, is greatly influenced by their occurrence as isolated groves in a Dry Forest and woodland matrix. The integrity of isolated moist pockets and the infrequent fire regime may be maintained when adjacent forests or woodlands are much drier (steep moisture gradient) and burn frequently. This occurs in Moist Forest sites in wet depressions or fringing wetlands. With frequent ignition sources, light fuels in the dry matrix burn before heavier fuels in the moist area dry out enough to burn. An increase in both fire frequency within Moist Forest patches and fire severity over the landscape matrix may occur in contiguous forest areas composed of a Dry/Moist matrix. This occurs when fuels accumulate in adjacent Dry Forests (e.g. more mesic dry types or denser, fire-suppressed conditions).

The typical canopy structure in Moist Forests ranges from relatively even-aged or two-storied to uneven-aged and patchy in mixed-species, old-growth stands. The overstory is typically closed in young to mature forests, with an intermediate canopy of tolerant species developing in gaps during prolonged fire-free intervals. Cedar and hemlock seedlings and saplings are few to many in patches of varying size, depending on time since fire. Competition-related mortality rates are high in patches of Douglas-fir during the stem exclusion stage of development after disturbance. Small trees are abundant, though few survive to dominant size due to competition.

Moist Forests are typically unstable habitats at the landscape level (1,000- to 10,000-acre scale) and particularly at the stand level. Forest structure is dynamic throughout the cycles of severe disturbance, regeneration, and secondary succession.

Current Conditions in Moist Forests Relative to Historic Conditions

For the longer fire cycle of Moist Forests, the rarity of fire during the last 60 years is not unusual given the predominance of young stands regenerated after logging and fire. However, the absence of fire in the adjacent Dry Forest matrix affects the long-term fire potential across the landscape, including the Moist Forest.

Soil disturbance was negligible under the historic fire disturbance regime. Variable levels of soil disturbance now coincide with canopy openings caused by harvesting. Red alder has greatly increased in abundance after logging and soil disturbance in Moist Forest associations. Currently, a mixture of native and exotic herbaceous species also increase with moderate to severe

disturbances. Scotch broom invasion is rare in the interior forest, being generally limited to larger openings created in proximity to woodland and prairie areas.

The recent predominance of dispersed thinnings has maintained relatively uniform disturbance and partial canopy cover, producing well-developed and uniform understory cover of characteristic shrubs and tree saplings in many stands (average understory cover 43 percent, Appendix A-7) . Small scale (30-300 ft) patchiness and clumpiness is low both in the overstory and understory under dispersed thinning regimes (67 percent of stands are uniform).

Outside of several outstanding residual forest stands (totaling about 500 acres), trees older than 100 years are rare or absent. The frequency of large Douglas-fir and cedar trees (>36 inches dbh) across the landscape is only one-tenth of that in historic Moist Forests (Appendix C-5). As with Dry Forests, the relative abundance of medium-sized trees (20 to 28 inches dbh) is about twice that of the historic landscape. With repeated thinning from below and the predominance of the 40-60 year-old age class, there is a lower relative frequency of smaller trees (<12 inches dbh) compared to estimates for historic forest. The historic Moist Forest may also have had a larger component of young stands, as indicated by both the high frequency of 6-12 inch trees and the extensive areas of fire-killed timber noted in 1853 (Appendix C-1).

Significant large snags and dead wood are relatively rare compared to natural Moist Forests (Appendix A-7). The natural legacy of snags and coarse woody debris was removed by extensive clearcutting in Moist Forest (RTA) during the 1930's. More recently, hazard tree reduction programs (for military helicopter safety) removed most remaining spike-top snags. However, both down dead wood and snags are 2 to 3 times more abundant than in dry forests, and significant concentrations occur in several Moist Forest reserves. Average annual rates of mortality are also much higher in the Moist Forest compared to dry forests. Competition-related mortality is relatively high in young Moist Forests while harvest-related removals have been relatively low.

The root disease*, Phellinus weirii,* is also a significant factor affecting the structure and pattern of Moist Forests at Fort Lewis. Three out of 25 Moist Forest plots (12 percent) across the Fort had major pockets of mortality from *Phellinus*. Only two of the 20 known locations of *Phellinus* were located in the RTA, where Moist Forests are most common. However, observations indicate that *Phellinus* is scattered throughout the RTA, suggesting a higher incidence than is currently mapped. Accelerated succession to redcedar may be a common consequence of *Phellinus*-induced mortality in Moist Forests.

Oak Woodlands

Oak was a major component of various woodland and savanna types covering about 13 percent of the historic landscape. Currently, Oak Woodland types cover only about 6 percent of the landscape and they are much less open than the woodlands maintained by historic fires. Due to the infrequency of oak types, these types cannot be characterized by the extensive sampling from the permanent plot grid. Assessment of current conditions in Oak Woodlands are based on field observations and on plot sampling done by Ryan and Carey (1993) as part of their study of habitat for western gray squirrels. Stem density of historic Oak Woodlands (n = 13 bearing-tree points) averaged 8 trees per acre and ranged from 1 to 40 trees per acre. Average tree size was 18 inches, ranging from 4 to 45 inches. Current Oak Woodlands have a much higher density of stems, averaging 93 trees/acre with a range of 5 to 180 trees/acre. Small stems are abundant in the oak types and average tree size is 8 inches dbh, ranging from 5 to 16 inches. The Douglas-fir component is also much higher in current woodlands (48 percent by basal area today versus 17 percent historically). Active invasion of Oak Woodlands by Douglas-fir is continuing; dying, suppressed oaks are common in ecotones between woodlands and dense forest.

The Fort Lewis Integrated Natural Resources Management Plan identified Oak Woodlands as an important ecosystem in need of its own management plan. Fort Lewis completed A Management Strategy for Oak Woodlands of Fort Lewis, Washington, in 2002 (GBA Forestry 2002) (Appendix A). The Oak Strategy provides more detail on the distribution, structure, and species composition of Oak Woodlands.

Pine Savanna

About half of the historic woodland/savanna was a ponderosa pine type, characterized by very low densities (0.4 to 4 trees/acre) of large pine (20 to 48 inches dbh). This is similar to the pine savanna structure hypothesized by The Nature Conservancy (1994). No ponderosa pines or pine types were noted outside of open savannas in the 1850's, though occasional pines too infrequent to be noted as a type or appear as bearing trees may have occurred in mixture with Douglas-fir in forests.

Forests with a significant component of pine cover about two percent of the current landscape. Present-day ponderosa pine types are quite variable and of much higher stem density than historic pine savanna. Most pine now occurs in a relatively dense, closed-canopy forest mixed with Douglas-fir and minor amounts of residual oak trees or sprouts. More open Pine Woodlands occur in some areas, typically with invading scotch broom, and sometimes with oak (Foster 1997).

There are also many grassland areas with scattered or clumped ponderosa pine, though only about 300 acres have been identified as important areas for restoration of pine savanna (Foster 1997). Ponderosa pine is also a minor and diminishing component of larger areas dominated by Douglas-fir in areas historically occupied by pine savanna. The various pine types are represented within the Bower Woods Research Natural Area.

Wetland/Floodplain Forests

About 1.5 percent of the landscape is occupied by various types of Wetland or Floodplain Forests. High water table and/or poor soil drainage associated with wetland margins or depressions produce forested wetlands on siltloams or muck soils (Group IV and Group VI soils), dominated by Oregon ash, willow, and lesser amounts of black cottonwood and occasionally trembling aspen. Floodplain Forests near the Nisqually River are situated on better-drained but seasonally flooded soils where black cottonwood is often the dominant species. Very little information is available about Wetland/Floodplain Forest structure and dynamics at Fort Lewis.

Other than the absence of fire on the dry margins of wet depressions, current vegetation processes are probably similar to historic conditions within larger forested wetlands on muck soils. Smaller wet areas on upland sites were more subject to fire and logging and most of these areas are of similar age and state of recovery as the surrounding upland forest.

Some aspects of floodplain disturbance regimes have been changed by flow controls imposed by dams on the upper Nisqually River. However, the lower Nisqually River at Fort Lewis still floods periodically and all major areas of floodplain riparian forest are protected within the Nisqually River Corridor and Nisqually Floodplain RNA.

5. ECOLOGICAL LANDSCAPE UNITS (ELU'S)

At the next higher level of organization, Ecological Landscape Units (ELU's) are defined by characteristic proportions of each community type and spatial patterns of interaction between types, as controlled by underlying landscape attributes of topography, soils, and hydrology. The prevailing character of human impacts and continuing needs for military training are also important ecosystem drivers which must be incorporated in the determination of ELU's. Each ELU has a distinct set of conditions (current and future-desired) that will require different management strategies.

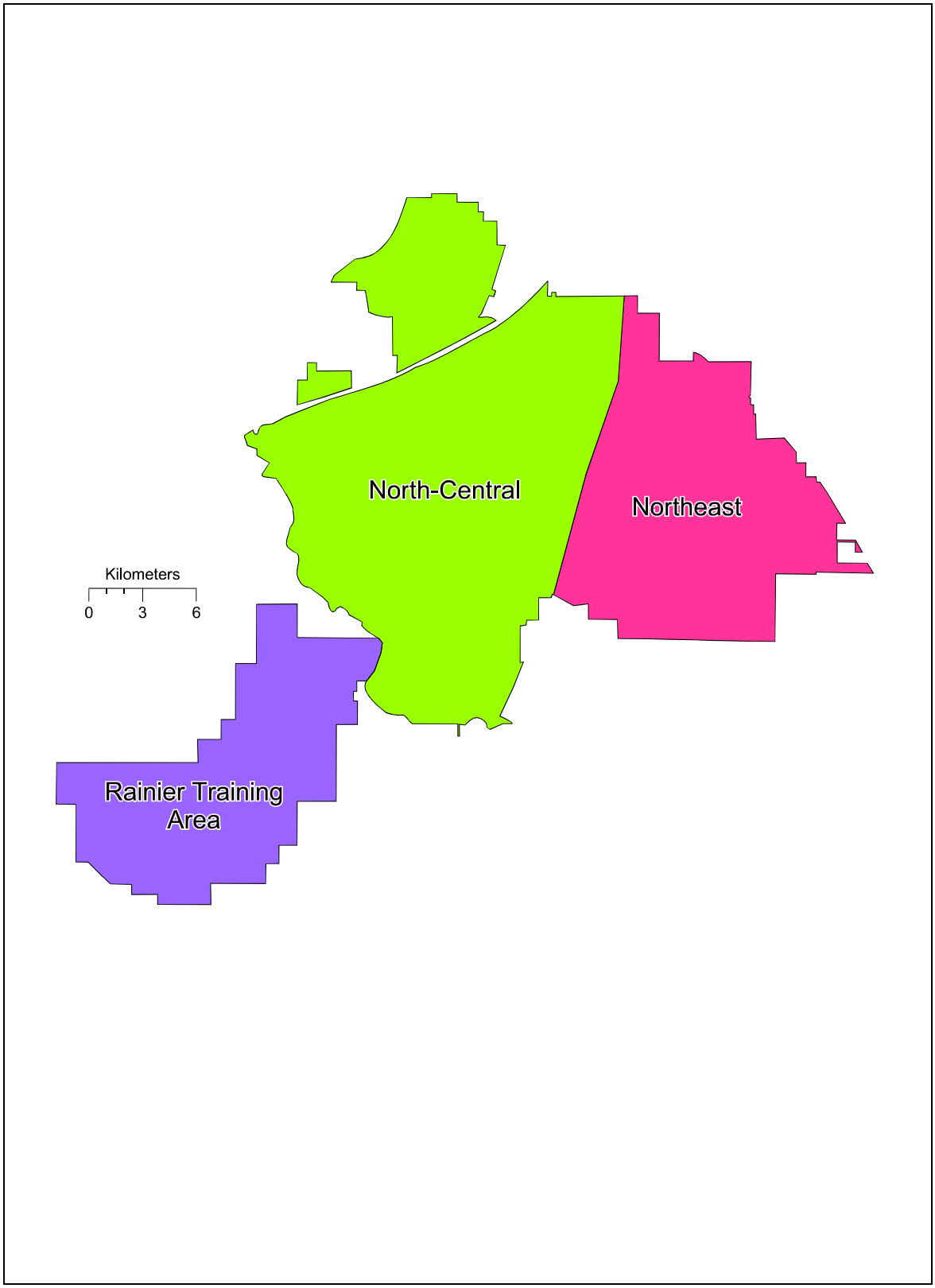
Watershed boundaries are incorporated to some extent in the determination of ELU's, particularly south of the Nisqually River. Compared, however, to many forested landscapes, the gentle topography and the poorly defined nature of surface water basins at Fort Lewis reduces the usefulness of watershed basins as ecological units.

Three ELU's are delineated as follows (Figure 13): the North-Central Fort (NC - 45,540 acres), the Rainier Training Area (RTA - 18,066 acres), and the Northeast Fort (NE - 23,375 acres).

North-Central ELU (NC)

The North-Central ELU is composed of several distinct landscape subunits determined by the combination of natural features and historic land use. This produces a coarse-grained mosaic of

Figure 13
Ecological Landscape Units at Fort Lewis



Source: Fort Lewis Forestry Program.

large, discrete blocks with different strategic priorities. A preliminary delineation of subunits is suggested below (acreage summarized from DEH Forestry Stands Database):

- Moist Forests occur in relatively small, isolated patches or strips associated with occasional moist slopes and wetland depressions within a Dry Forest matrix. Larger areas of Moist Forest occur on Argonne/Marne Forest (12,900 acres) - Features include two large areas of relatively complex forested hills constituting the largest blocks of contiguous historic forest within the ELU.
- Central Impact Area Forest (8,970 acres) - Features include a large unmanaged forest in the small arms impact area, and smaller forest blocks on Cherry Hill, Kicker Hill, and Murray Creek. Ponderosa pine are a significant component.
- North Fort Lewis/Puget Bluff forest, (6,676 acres) Natural features include one large forest block bordering Puget Sound, and other small forested areas, large lakes, and marshes maintained among the urban uses and facilities of North Fort Lewis. The unit is separated from the remainder of the post by Interstate Highway 5.
- Main Cantonment area (5,600 acres) The unit is dominated by buildings, facilities, and various developed grounds.
- Nisqually River / Muck Creek Corridor (5,722 acres) Features include contiguous forested blocks and corridors, that provide connectivity between other landscape units.
- Artillery Impact Area (5,644 acres) One large block is dominated by prairie and allocated to artillery training.

Landtype distribution

The majority (70 percent) of the NC ELU is outwash plains and terrace (Appendix A-5, also see Figure 2), historically occupied by prairie and woodland with some forested areas on topographic breaks between outwash terraces or outwash channels. About 23 percent of the ELU is relatively hilly terrain on till deposits, occurring in several distinct blocks which were historically forested. These blocks provide the basis for the separate, somewhat isolated forest subunits described above. Another 7 percent of the ELU is in other landtypes, including steep breaks to the Nisqually River or Puget Sound (4 percent), alluvial deposits (2.5 percent), and poorly-drained peat or muck soils (0.5 percent). Wetlands, marshes, and lakes are relatively large but infrequent, covering about 3.6 percent and occurring primarily as major depressions in gentle outwash/drift topography. breaks and flats in the Nisqually River/Muck Creek corridor and Puget Sound Bluff and also on the northwest slope of the Argonne forest. Wetland/Floodplain Forests in the Nisqually River/Muck Creek corridor are also significant, accounting for about 3.5 percent of the total forest area in the NC and providing connectivity between the RTA and other forested subunits of the NC.

Landtype distribution

The majority (70 percent) of the NC ELU is outwash plains and terrace (Appendix A-5, also see Figure 2), historically occupied by prairie and woodland with some forested areas on topographic breaks between outwash terraces or outwash channels. About 23 percent of the ELU is relatively hilly terrain on till deposits, occurring in several distinct blocks which were historically forested. These blocks provide the basis for the separate, somewhat isolated forest subunits described above. Another 7 percent of the ELU is in other landtypes, including steep breaks to the Nisqually River or Puget Sound (4 percent), alluvial deposits (2.5 percent), and poorly-drained peat or muck soils (0.5 percent). Wetlands, marshes, and lakes are relatively large but infrequent, covering about 3.6 percent and occurring primarily as major depressions in gentle outwash/drift topography.

Fire

Dry Forests in the interior of the larger contiguous forest blocks in the Argonne/Marne and North Fort/Puget Bluff subunits were probably subject to relatively infrequent and severe fires due to the limited interaction with prairies and woodlands (infrequent ignitions and more continuous fuel loading - see discussion p. 65-66). Forests within subunits containing the mixed mosaic of prairie, woodland, and Dry Forest would have been subject to frequent low intensity fires maintaining more

variable, mixed-age structure (Central Impact Area and southwest part of Argonne/Marne subunit). Thus, historical disturbances maintained a variable combination of both even-aged stands and patchy, multi-aged stands across the ELU.

Current fire ignitions are relatively frequent, due primarily to accidental military ignitions, with recent (< 25 years) low intensity fire noted on 10 percent of the Dry Forest plots and charred trees or stumps from older fires (continuous range from 25 -100 years) noted on 38 percent of the plots. The real extent and severity of recent fires is low, however.

Harvesting disturbance and current structure

Medium age-classes of trees are predominant (66 percent of the forest 45-85 years old) but significant stands of older trees occur (16 percent >85 years). Areas with significant older stands There is a diverse harvesting history within and among the forested blocks (Appendix A-4), including the Nisqually River and Muck Creek corridors (105-114 years, some >200 years), Puget Bluff forest (220 years), the Marne Forest (95-105 years), and Kicker Hill (140 years). Some residual old trees occur in about 30 percent of the younger forests (< 85 years).

Watersheds

About 25,000 acres of the southern NC ELU is in the Nisqually River watershed, comprised of Muck Creek, (37%) Salmon Creek. (13%), and Murray Creek (5%) sub-basins. The Sequalitchew Creek (American Lake) watershed occupies 39 percent (17,700 acres) of the NC in the north, draining directly into Puget Sound. The northernmost 6 percent of the NC along Puget Sound is in the Solo Springs sub-basin of the Chambers Bay watershed. As mentioned previously, surface drainage features are indistinct and groundwater drainages are most important.

Military use

Military use is varied and intensive in the NC, including 8,200 acres of developed facilities and housing and 15 designated training areas. Large areas are dedicated to fairly exclusive military use for artillery and small arms training, including the Artillery Impact area, the Central Small arms impact area, and two smaller forested impact areas. The small arms impact areas are generally off limits to both foot and vehicle traffic with the exception of fire road maintenance and occasional surveys. Training activities in other forested areas include intensive infantry exercises and use of incendiary devices, heavy vehicle traffic on and off-road, and helicopter exercises (reconnaissance, landing, and lifting).

Northeast ELU (NE)

Landscape subunits within the NE are not defined at this time. The combined right of way for State Highway 507 and the adjacent railroad is fenced on both sides, bisecting the ELU and constituting a significant barrier to some wildlife. A logical subunit could be based on this barrier.

Landtype distribution

The great majority of the NE (89 percent) is outwash plains and terrace (Group I soils), historically dominated by prairie and woodland with some forest on topographic breaks between terraces or channels. Only 7 percent of the area is relatively hilly terrain on till deposits (Group II soils) that was historically forested in small contiguous blocks. Significant areas (4%) of poorly drained soils (Group IV) are associated with the large marshy depressions and Muck Creek. This ELU contains a mixture of both gradual and abrupt topographic breaks.

A major concentration of wetlands, marshes, and lakes extends from Spanaway marsh through the Muck Creek corridor. These waters are large and occur primarily as depressions in gentle outwash/drift topography. The influence of these waters is indicated by the occurrence of water near 14% of the forest inventory plots. Wetlands are relatively infrequent outside the major wetland area.

Distribution and interaction of community types

The current vegetation cover is 62 percent forested, 24 percent prairie, 6 percent woodland and 6 percent water. Colonization Dry Forest comprises about 50 percent of the total forest, greatly

increasing the predominance of Dry Forests (now about 90 percent of the forest) and reducing the mixed-mosaic character of the landscape (Appendix A-1). Historical Moist Forests are concentrated around major wetland areas with relatively abrupt transitions at dry ecotones. A few areas of Moist Forest occur in relatively small, isolated sites associated with moist slopes or wetland depressions away from the major wetland areas. Wetland/Floodplain Forests generally remain intact and account for about 2.5 percent of the forest area.

Oak Woodlands are reduced to about 60 percent of the historic area of oak. The current area of prairie is only about 43 percent of the historic prairie area. Ponderosa pine is a significant

component, mixed with Douglas-fir in about 5 percent of the forest in the NE ELU. Open savannas of ponderosa pine/oak used to occupy about 13 percent of the ELU. Though many areas of historical pine/oak savanna have been colonized by Douglas-fir, scattered or clumped ponderosa pines occur in some open areas currently typed as non-forest. The extent and condition of these areas is not well defined at this time an should be surveyed.

Historically-forested areas in the NE occurred in intimate mixture with predominant prairie and woodland types in a relatively open landscape mosaic. Forested areas were primarily associated with 1) the series of marshy depressions extending from Spanaway marsh to Chamber's Lake, and 2) occasional hills or topographic breaks between outwash terraces or outwash channels. This historic mosaic was relatively stable, with large patches of different forest and woodland community types intermixed in roughly equal proportions with a larger proportion of prairie. The historic, open mosaic character persists to some extent, in spite of the large increase in forest cover in the NE. Ecotones between forest, woodland, and prairie are still relatively abundant, and declining remnants of oak and pine woodlands are intimately mixed within the dominant Douglas fir matrix.

Fire

The predominant Dry Forests in the pre-settlement landscape were subject to relatively frequent fires of low to moderate intensity due to frequent margins and gradual ecotones with woodlands and prairies in the NE ELU (see discussion p. 65-66). This would have maintained typical Dry Forest structure characterized by a patchy, multi-aged canopy, low fuels, and high mortality rates for small trees.

Current fire ignitions are relatively frequent, due to accidental military ignitions, with recent (<25 years) low intensity fire noted on 8 percent of the Dry Forest plots and charred trees or stumps from older fires (>45 years) were noted on 28 percent of the plots. Prescribed fire is increasingly common on margins of Dry Forest with the recent burning program for maintenance of prairies. No signs of recent fire were noted on plots in Moist Forest in the NE, though charred trees or stumps from older fires (>45 years) were noted on 33 percent of the plots in Historical Moist Forest.

Harvest disturbance and current structure

The forest harvesting history is quite diverse in the NE (Appendix A-4); 45-85-year age-classes are most common (62 percent of forest) but significant areas of older age-classes (25 percent >85 years) are dispersed through the ELU. Significant uneven-aged structure is developing both within and between stands and about 30 percent of the young timber stands (>85 years) contain older residual trees. Douglas-fir regenerates readily in the understory even after moderate to light thinnings. Hardwoods and cedar are a very minor intermediate canopy component outside of very moist areas.

Watersheds

The northern 27 percent of the ELU is in the Spanaway Creek sub-basin of the Chambers Creek watershed, providing a substantial portion of the forest cover for this urbanized water basin. The southern 73 percent of the NE is in the Nisqually River watershed within the Muck Creek (57 %), South Creek (5%), and Lacamas Creek (5%) sub-basins.

Military use

There are eight designated training areas, and one ammunition storage area. Military use is intensive: vehicles on and off road, tank training, aircraft, high intensity foot soldier training. In the extensive forested areas with gentle slopes, both the requirement for vehicle access and potential impact of vehicles is high. Training use is a significant factor affecting understory vegetation and disturbing and reducing down woody debris.

Rainier Training Area ELU (RTA)

Landtype distribution

The RTA has the most complex terrain on the Fort, with frequent hills, ridges, and wet depressions, primarily associated with moraine or till deposits. This terrain is dominated by Group II soils (46

percent of ELU) with significant inclusions of Group III (16 percent) and Group VII (7 percent) soils that are uncommon or absent in the other ELU's. The outwash plains and terrace (Group I soils), so predominant North of the River, occur on only 26 percent of the RTA.

Wet sites are relatively well dispersed throughout the RTA in association with wetlands, marshes, and lakes that occur in frequent depressions in the complex, hilly terrain (3 percent Group IV soils). The relatively high frequency of wetlands in the RTA is also indicated by the occurrence of water near 21 percent of the forest inventory plots.

Distribution and interaction of community types

The current vegetation cover is 84 percent forested, 4 percent woodland, and 10 percent prairie. About 10 percent of the forest is Colonization Dry Forest, expanding onto Group I soils at the expense of prairies (previously 14 percent) and woodlands in post-settlement times. Oak Woodlands have also colonized previous prairie areas and the current proportion of Oak Woodlands is slightly greater than historic estimates. Wetland/Floodplain Forests are generally intact, and account for about 1 percent of the forest.

The RTA contains the largest contiguous area of forest (approximately 14,000 acres) on the Fort. More than half of the forested area is in Moist Forest. Significant portions of the Moist Forest are currently occupied by red alder, providing the only extensive, moist upland hardwood forest on the installation. Dry Forest types frequently include moister associations such as Douglas-fir/hazel/swordfern and Douglas-fir/salal-oceanspray.

The complex terrain produces small-scale heterogeneity, with frequent intermixing of moist and dry forest types, even at the stand level. Here, as indicated by historic fires, there is potential for a moderate to high severity fire regime across a mosaic of moist and dry forest patches.

Prescribed fire is common on margins of Dry Forests because of the recent burning program for maintenance of prairies. Though military ignitions are frequent in the interior forest, no signs of recent (< 25–year-old) fires were detected on inventory plots, indicating the low intensity and small size of these fires. Charred stumps and trees from older fires (> 45 years) are common, being found on 56 percent of the inventory plots.

Harvest disturbance and current structure

Almost all of the forested area was clearcut and burned in the 1920's and 1930's, leaving a large block of similar age class (68 percent 45-65 years old) and removing most large wood over the entire ELU. Less than 1 percent of the stands are older than 85 years and residual old trees are found in only about 7 percent of the young timber stands. Thus, the majority of the forest is even-aged, older age classes are absent, and structural diversity is low both within and between stands.

Douglas-fir is generally not reproducing in partial cuts on dry sites within the hill complex. Maple, cedar, and hemlock are currently the major intermediate canopy components.

Watersheds

The western 57 percent of the RTA provides the major forested watershed for the Spurgeon Creek and Skookumchuck Creek sub-basins of the Deschutes River. The eastern 43 percent of the RTA

provides most of the forested watershed area for the Thompson Creek sub-basin of the Nisqually River. There are no year-round streams, though small lakes and wetlands provide frequent areas of surface water. Thus, the hydrology is dominated by groundwater drainage which directly feeds the Nisqually River and other streams outside of the Fort.

Military use

Military use is primarily low-intensity foot soldier training, occurring within five designated training areas. In the hilly terrain, vehicles are generally restricted to maintained roads and non-forested landtypes, producing a low requirement for, and impact of,military vehicle use in the forest.

III. ECOSYSTEM MANAGEMENT STRATEGY

Ecosystem management strategies are developed from the Guiding Principles, with priorities and constraints set here to integrate multiple and sometimes conflicting goals. Using concepts of ecosystem management, forest management strategies are formulated within the ecosystem framework.

A. PRIORITIZATION OF MANAGEMENT GOALS AND DIRECTION

1. INTEGRATION OF HUMAN GOALS WITHIN THE CAPABILITIES OF ECOSYSTEMS

The formulation of strategic goals and prioritization of management treatments for Fort Lewis is based on the integration of (1) ecosystem capabilities, (2) management capabilities, and (3) human goals and desires. Historical ecosystems and ranges of variation provide a basis for understanding the capability of Fort Lewis ecosystems under a given disturbance regime. Both current and historical ecosystems at Fort Lewis are characterized by a wide range of potential conditions, very much dependent on disturbance regimes. Management strategies for current ecosystems must be developed within the context of human goals and management capabilities that now determine the predominant disturbance regimes.

The three top priorities for future management direction are summarized below:

Develop and maintain late successional forests in order to:

- meet the legal requirement to provide for recovery of the northern spotted owl
- provide habitat for many species in a landscape devoid of older forests
- address both social and ecological needs for maintaining a component of older forest across the landscape

Maintain and restore native biological diversity and unique habitats including:

- Ponderosa pine
- Oregon white oak
- various wetland types
- various successional stages of all community types
- other minor but special plant communities

Maintain low risks of catastrophic fire for protection of:

- adjacent human communities
- military training areas
- late-successional forest
- special or rare habitats of regional value

Mature Forest Systems at Fort Lewis

Past management has maintained forest cover and a maturing forest landscape with many options for the future. However, general strategies for this forest were not aimed at development of mature forest structure or complexity. The listing of threatened or endangered species such as the northern spotted owl immediately increases the emphasis on development of appropriate mature forest habitats. Of even greater significance, however, is the increased recognition of the need for a balanced proportion of various forested ecosystems for the sake of all inhabitants of the landscape, people included. Management strategies for Fort Lewis favor development of mature forest ecosystems to benefit many species in the Puget Lowlands, a landscape that is generally lacking in mature forest cover.

Many public forests are developing comprehensive strategies to maintain whole ecosystems, in part due to the inadequacy of single-species management and a continuing occurrence of species being listed under the Endangered Species Act. Ecosystem management can provide for individual species of concern only within certain capabilities of the ecosystem, without generating other imbalances that may threaten new species of concern or even the integrity of the ecosystem (e.g., catastrophic fire). The strategy for mature forests at Fort Lewis is the natural outcome of goals formulated to provide a range of forest structure and composition, somewhat representative of that which functioned historically, based on the concept of native ecosystems as proven models of healthy forests.

Biodiversity Values at Fort Lewis

The overall quality and diversity of habitats on Fort Lewis play a critical role in supporting native species and communities within the South Puget Sound region. Moreover, as no other largely undeveloped areas remain in this region, Fort Lewis represents the final stronghold for many threatened native species or habitats. For example, within Puget Sound the ranges of the western gray squirrel and ponderosa pine are entirely restricted to Fort Lewis. Similarly, many of the components of historic prairie landscape systems (e.g., Idaho fescue grasslands, Oak Woodlands, associated vertebrates and invertebrates) are best represented on the Fort. If these and other threatened species and communities are to be maintained in the future, their continued viability on Fort Lewis lands is vital.

Forest management at Fort Lewis will play an important role in maintaining or restoring unique vegetation communities and wildlife habitats. The promotion of mature forest structures over the long term should help provide habitat for species associated with these structures, including the northern spotted owl. Many other mature forest associates are currently threatened or declining (Appendix G). Similarly, the restoration of Oak Woodlands, ponderosa pine forests, and Douglas-fir savannas is also an important goal, and will depend on well-designed, selective timber management techniques. Some communities, habitats, and species, however, may be particularly sensitive to disturbances related to timber harvest (e.g., *Howellia aquatilis*, and wetland and riparian systems), and therefore dictate that such management be carefully evaluated with respect to multiple ecological scales.

Risk of Catastrophic Fire

As much as possible, forest ecosystems at Fort Lewis must now be managed for a low risk of catastrophic fire, in order to develop a relatively stable and sustainable set of environments within the Fort Lewis Military Reservation. As development continues in surrounding areas, Fort Lewis' ecosystems become increasingly valuable as regional natural reserves. Historic ecosystem processes such as large, stand-replacement fires would threaten both Fort Lewis reserves and adjacent human communities.

B. KEY ELEMENTS OF ECOSYSTEM MANAGEMENT

1. CONSERVATIVE AND ADAPTIVE MANAGEMENT

Since the 1950's, the conservative program of thinning, selection harvest, and overstory removals at Fort Lewis has hastened forest development in small increments while maintaining a maturing forest landscape. These practices have retained many options for the future and provided opportunities for experimentation and adjustment of treatments. Management practices have been adaptive, both in terms of adjusting to new societal goals and being responsive to lessons learned from past practices.

This process of conservative and adaptive management will continue, particularly in the application of new strategies to maintain or restore "natural ecosystem functions." Our ability to understand or even characterize ecosystem functions is not well developed. Thus, the proposed strategy for managing ecosystems in this document is a "working hypothesis." Relative to historic conditions, the Fort Lewis environment is subject to several new, persistent processes:

- periodic mechanical disturbances

- prescribed fires burning under relatively moist conditions
- suppression of fire during low-moisture conditions
- aggressive, exotic plant species

Over time, as the response of Fort Lewis' ecosystems to management under this new disturbance regime becomes apparent, successful strategies can be improved and applied to larger areas. This process of adaptive management will be based on monitoring the effects of both experimental and operational treatments in pertinent ecosystems.

2. MULTIPLE SCALES

Management activities will be designed and controlled across multiple landscape scales. Cumulative effects should be monitored and assessed within the ecosystem framework from fine to coarse scales, a process greatly facilitated by Geographic Information System (GIS) analysis. Major scales or levels of organization pertinent to Fort Lewis are:

- Regional: Fort Lewis in relation to ecosystems in the Western Washington Lowlands, adjacent to the Olympic and Western Cascades Provinces. Economic Region of Influence for adjacent human communities in Pierce and Thurston Counties (1,063,000 acres)
- Fort Lewis: overall condition of Fort Lewis ecosystems (86,400 acres)
- Ecological Landscape Units within Fort Lewis: 18,000 to 45,000 acres
- Vegetation communities: vegetation community types occurring on Fort Lewis are repeated in characteristic proportions across different landscape units
- Landscape subunits within ELU's: 1,000 to 12,000 acres
- Forest Stands: 10 to 500 acres
- Structural variation and pattern within stands: 0.1 to 5 acres

3. COARSE FILTER / FINE FILTER CONCEPT

According to the **coarse filter** concept, most native plants and animals should be ensured appropriate habitat simply by maintaining or restoring a functional range of ecosystem conditions at appropriate scales. Strategies for this at Fort Lewis apply our understanding of the historic range of ecosystem conditions as a basis for the "functional" range of conditions. The strategic goals for maintaining mature forests and biodiversity (Sec. III.A.1) provide two of three major strategies for the coarse filter approach at Fort Lewis. Combined with these, maintenance and protection of all waters, wetlands, and riparian zones should provide habitat for the great majority of native inhabitants.

Although the coarse filter will benefit most species, including listed species of concern, some species or resource goals may require emphasis on certain habitat elements with specific measures taken to ensure habitat. These specific measures, or **fine filters**, are discussed for specific goals or species of concern in Section IV of this document, in the Fort Lewis Fish and Wildlife Management Plan (U.S. Army 1998) and in the Northern Spotted Owl Habitat Conservation Plan (Bottorff 1994).

4. CONSERVATION RESERVES

The primary purpose of **conservation reserves** is the protection or restoration of critical ecosystems or components. Ideally, the most intact, remnant ecosystems or components are protected and maintained. Where possible, declining native ecosystem types within reserves are restored. Therefore, reserves serve as fine filters for the protection of species of concern or as coarse filters with respect to native communities.

In addition to the protection of species and communities, conservation reserves permit continuation of natural ecological processes and the opportunity for us to better understand these processes. As core areas within human-modified landscapes, conservation areas are a possible source of

native species, ecological processes, or scientific knowledge that could aid the restoration of similar

or nearby habitats Reserves can also include areas that were impacted by human activities in the past (e.g., logging) but are currently unmanaged, and thus serve as reference areas for natural recovery from past human disturbance in comparison to areas that continue to be subject to human manipulation.

With this revision of the Strategy, the Forestry Program establishes a system of Conservation Reserves, comprising 10,197 acres (Figure 14). These reserves consist of three types:

(1) **Research Natural Areas** (RNA's) were designed and established by the Army at Fort Lewis in early 1994 (The Nature Conservancy 1994). These areas are the Bower Woods RNA (1,739 acres), Ellsworth Woods RNA (410 acres), Nisqually Floodplain RNA (1,300 acres), Thirteenth Division Prairie RNA (234 acres), and Weir Prairie RNA (1,096 acres). Bower Woods, Ellsworth Woods, and Nisqually Floodplain are almost entirely forest, and Weir Prairie contains oak woodlands. On public lands, RNA's are generally established for three purposes: (1) to preserve examples of all significant natural ecosystems for comparison with those influenced by humans, (2) to provide educational and research areas for ecological and environmental studies, and (3) to preserve gene pools of common and rare plants and animals. At Fort Lewis, RNA's are managed to accommodate necessary military uses, while preserving the ecosystems and species that make these sites significant from a regional perspective. Total = 4,779 acres.

(2) **Natural Reserves** are areas that have similar conservation values to formal RNA's, but have not been designated as such. These include the steep bluffs above Puget Sound and along the north side of the Nisqually River, which preserve patches of old-growth forest and many natural springs on Fort Lewis, and the unmanaged riparian forests along the Nisqually River. These areas are exempt from commercial timber harvest for the duration of this Strategy revision, but ecological restoration may occur. Total = 4,074 acres, of which 1,721 acres are contained within RNA's.

(3) **Reference Stands** do not usually have high conservation value in the sense of being unique or rare habitats. Rather, these are forest stands that have not been managed by the modern Fort Lewis forestry program, which began in the early 1960's. These stands consist of two types. The first type are historically-forested areas (both Moist and Dry) that were clearcut prior to the 1960's by the Army, or private timber companies in the RTA, and have regenerated naturally. The second type are Colonization Dry Forests that have never received timber harvest. These stands serve as reference or control areas for comparing the effects of variable-density thinning and other kinds of timber management on the course of forest development. The Intensive Stand Inventory (Appendix D) monitors five of these stands. These areas are exempt from all timber harvest for the duration of this Strategy revision. Total = 3,395 acres, of which 330 acres are contained within RNA's.

Conservation areas and other core areas are described for each ELU in Section III.D.

C. STRATEGIES BY COMMUNITY TYPE

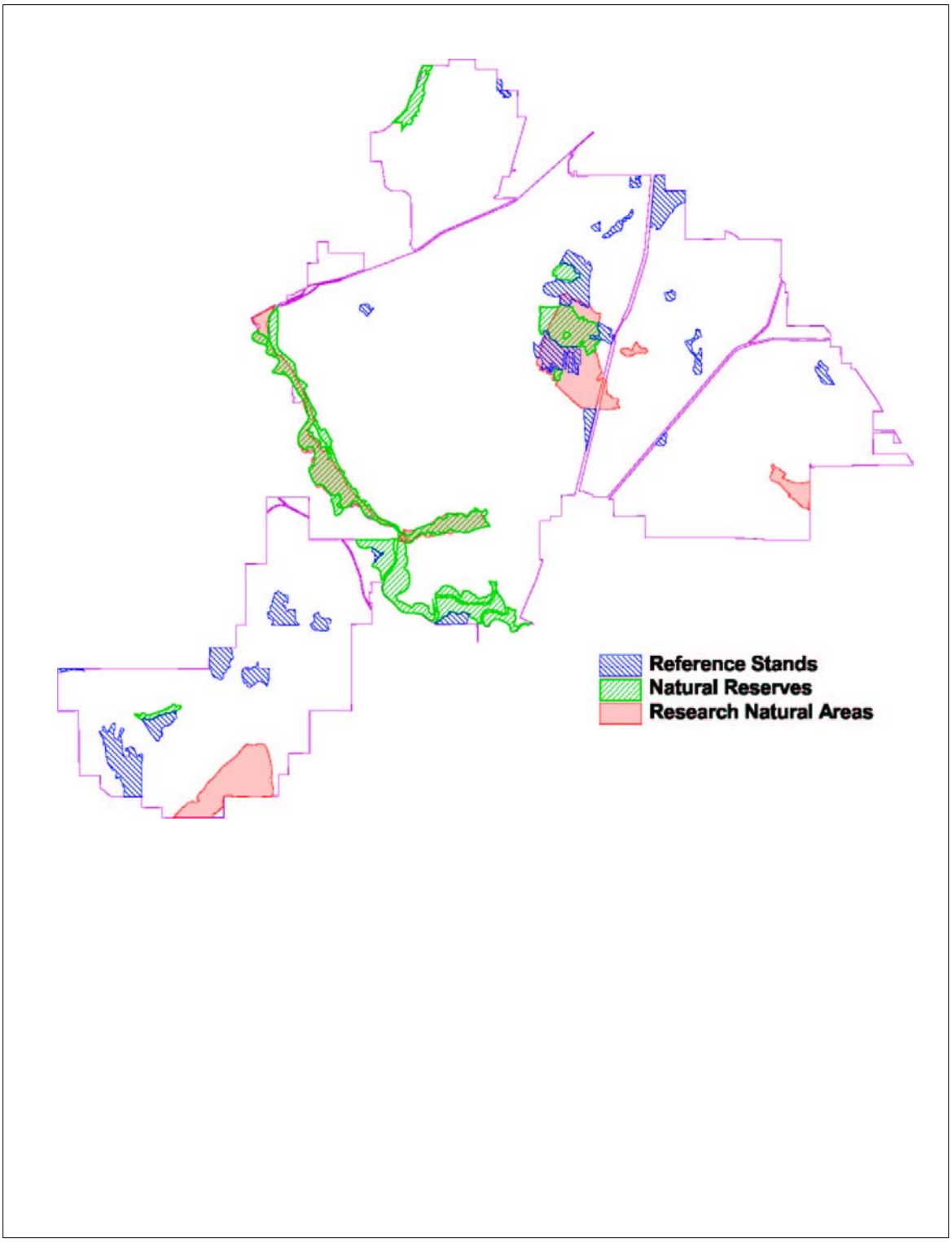
Primary management strategies and priorities for treatment are discussed below for each community type. Opportunities for treatments and recommended silvicultural objectives for community types are developed further in Section III.D, based on conditions within each Ecological Landscape Unit.

1. DRY DOUGLAS-FIR FOREST

A significant component of older trees occur on about 28 percent of the Dry Forests, many of these occurring as residual old trees in 45- to 85-year-old stands. The highest, short-term priority for management is to enhance this existing structure, and allow accumulation of snags and coarse woody debris. The second priority is to initiate structural diversity in younger, even-aged stands, though many portions of these stands can be allowed to develop large trees and understory structure without entry.

Multi-aged and patchy stand structure will continue to be developed and maintained by periodic disturbance (10- to 50-year cycle) in most Dry Forests. As in the native forests, Dry Forests can provide relatively stable mature forest conditions in a patchy, sometimes shifting mosaic of canopy

Figure 14
Conservation Reserves at Fort Lewis



Source: Fort Lewis Forestry Program

structure and woody fuels, both within and between stands. Maintenance of this structure in Dry Forests is a key element of the strategy for maintaining a fire-resistant landscape within largercontiguous areas of a Dry/Moist Forest matrix, and as part of the forest-woodland-prairie mosaic (see Section III.D.). Silvicultural treatments and accidental fire disturbances emulate processes in natural dry-site, Douglas-fir forests, including:

- Large trees developing relatively free of mortality, singly or in groups.
- Variable mortality of medium-aged trees; death or removal of individuals allows recruitment of intermediate canopy trees. Removal of groups favors Douglas-fir regeneration and desirable understory pattern.
- Frequent mortality in young patches (stocking control).
- Generally low fuel levels and patchy accumulation of fuels.
- About one-third of the oldest Colonization Forests (85- to125-years-old) may be suitable for application of the typical, Dry Forest management strategy. Colonization Forests are surprisingly productive and appear quite capable of supporting dense forest growth and continued accumulation of forest attributes (coarse woody debris, understory flora, belowground forest biota). However, many of the younger Colonization Forests contain remnant oak and pine components with potential for restoration. Problems with invasion of Scotch broom are also most prevalent in Colonization Forests. For these particular Colonization forests, the long-term objective is not creation of spotted owl habitat, but restoration of forest structure towards its putative condition at the time of first European settlement.

Under the Owl Plan (Bottorff 1994), it was recognized that the typical goals for accumulation of snags and logs, which were based on studies in moist old-growth, are unattainable in Dry Forests. Thus, the goals for logs and snags were set at half those for Moist Forests. The analysis by Ahrens (1988b) indicates that Colonization Forests, which have no legacy to start with, have even fewer snags and logs than Historical Dry Forests. Bottorff (1994) further realized that most Colonization Forests were not suited to the creation of owl roosting and nesting habitat, and at best could eventually become foraging habitat.

Specific Guidelines for Managing Dry Forests

Stability

Patch level: shifting patches, 0.5 to 1.0 acre. Stand level: relatively stable overstory cover, increasing age, increasing accumulation of forest elements (forest floor, debris, understory plants, fungi, succession of belowground flora and fauna, etc.), particularly in some recent colonizing forests. Landscape (ELU) level: stable or decreasing proportion of landscape; reduction due to maintenance or expansion of oak or pine at woodland ecotone or to continued site succession towards Historical Moist Forest types at moist ecotones.

Age-structure

Develop or maintain mixed age structure within and between stands. Expand older age-classes within and between stands. Dry sites in Open Mosaic landscapes develop toward uneven-aged condition. Some Dry Forest in a more moist landscape matrix develops into two-storied stands.

Canopy cover

Total canopy cover should be maintained at about 60 percent, assessed over a minimum area of five acres. With uneven-aged structure, assessments should include dominant, codominant, and intermediate canopies.

Stem density, stocking

Density of trees greater than 4 inches DBH from 150 to 230 trees per acre at maturity.

Species composition

Douglas-fir dominant at all canopy levels. Oak and pine components maintained at dry ecotones, moist-site hardwoods or cedar /hemlock components maintained at moist ecotones.

Species dynamics

Increasing diversity of shrubs and herbs with development of forest understory. Increasing component of oak and pine at woodland ecotone. Increasing component of cedar, hemlock, and maple at moist ecotone.

Disturbance frequency

Mature forest structure is generally developed and maintained by periodic disturbance at 10- to 50-year intervals. Some variation, including two-storied stands, can occur, particularly in moister associations or landscape contexts requiring occasional stand replacement disturbance, or where heavy shrub cover inhibits regeneration.

Scotch broom strategy

Pre-establish regeneration before reducing canopy below 30 percent in patches greater than one-half acre. Prescribed underburning at woodland or prairie ecotones.

Overstory/understory patchiness

Increase patch-diversity within stand. Develop a mixture of higher-density tree groups with low understory cover and lower-density tree groups with higher shrub, understory tree, and sapling cover.

Snags, coarse woody debris, fuels

Emulate historic, dry Douglas-fir type. Low fuels maintained by periodic thinning in small and medium size classes, and by prescribed underburning at open margins. Protect existing snags and down logs. Allow natural recruitment of large snags to achieve a minimum of two large snags per acre ($\geq$ 24 inches DBH, $\geq$ 20 feet tall) over the long-term in Historical Dry Forests, one large snag per acre in Colonization Dry Forests. Provide for accumulation of down logs to achieve a minimum of 120 feet of length per acre ($\geq$ 20 inches diameter, $\geq$ 20 feet in length) over the long term in Historical Dry Forests, 80 feet per acre in Colonization Dry Forests. Where needed, creation of coarse woody debris accompanies timber harvest.

Regeneration and stocking control strategy

Douglas-fir establishes in partial shade. Maintain overstory of 30% to 50% until established. Occasional overstory removal in 0.5- to 1-acre patches (with some retention) to maintain young age component. Precommercial stocking control may be desirable in young age classes within stands, particularly in Colonization Dry Forests. Artificial regeneration (tree planting) may be used to supplement natural regeneration.

Priority for selection of treatment units

Short-term priorities for treatment are:

- Stands adjacent to high-quality core areas of remnant Historical Dry Forest.
- Maturing stands with large remnant trees and immediate potential for multi-age structure.
- Dense, predominantly even-aged stands with low structural diversity.

- Colonization Dry Forests with intact but declining oak or pine, particularly those facilitating maintenance of adjacent, intact woodlands.

Stand units

Lay out stand units to include ecotones and accomplish treatments to maintain typical character of ecotone. Maintain diminishing component of Douglas-fir at woodland ecotones. Generally create or maintain abrupt transition at moist ecotone.

Treatment strategies for major silvicultural objectives

Development and maintenance of Dry Forest structure should be encouraged by the following treatments within patches or across stands. The treatments can be applied singly or in combination to accomplish major silvicultural objectives, as determined by current conditions:

- Thin overstory (variable density) in areas of uniform canopy to stimulate regeneration of Douglas-fir and native understory cover (maintain enough canopy cover to inhibit Scotch broom).
- Create new canopy gaps, or expand existing canopy gaps, by removing overstory trees, especially above existing patches of natural conifer regeneration. In stands where natural regeneration is rare or absent, followup quickly with artificial regeneration, before Scotch broom can get the upper hand.
- Favor existing, intermediate-canopy Douglas-fir by selective cutting of individual overstory trees.
- Retain and protect existing mature forest structure, including large live trees (sound or decadent), snags, and down wood.
- Maintain undisturbed patches of overstory Douglas-fir in portions of the stand to develop branch-free boles and sparse, shaded understory.
- Thin dense patches of saplings to maintain low stem density and increase growth of residual saplings, and to maintain some understory shrub cover. Favor existing pine, oak, and madrone saplings.
- Explore new techniques for harvesting and yarding small material with minimal soil disturbance.
- Select root rot pockets for heaviest thinning or group selection, and favor regeneration of oak, maple, or shrub cover, if necessary to avoid regeneration of Douglas-fir in infected areas.
- Light thinning or no-entry to maintain maturing overstory, low fuels, military vehicle access, and other future options in some relatively uniform, even-aged areas of Colonization Dry Forest (areas with low to moderate stocking, 80-120 sq ft per acre basal area)
- Regenerate early-successional patches in larger areas using shelterwood harvests and long-term retention of residual trees and snags (two-storied stands), followed by artificial regeneration, if needed. Occasional occurrence in landscape units historically subject to stand replacement fires across contiguous Dry/Moist Forest matrix.
- At maturity (existing or in the future), maintain Dry Forest structure in mature forests with periodic disturbance (variable-density thinning or fire) across all age classes. Emulate frequent, low-intensity fire disturbance regime.

2. MOIST DOUGLAS-FIR / REDCEDAR / HEMLOCK FOREST

In the short-term, the primary strategy for active management in Moist Forests is to initiate structural diversity and accelerate development of large overstory trees, snags, down logs, along with vertical and horizontal canopy diversity. Much of the existing mature forest structure in Moist Forests is concentrated in remnant patches of predominantly older forest in unmanaged areas (about 900 acres). Other existing mature stands or components in Moist Forests should be protected or maintained as core areas in managed stands. Development of Moist Forest structure in young stands can be encouraged as follows:

- Established, shade tolerant understory trees are favored by thinning some medium sized trees.
- Existing features including larger trees and snags or down wood, are retained and protected.
- In portions of the stand, development of closed canopy patches of Douglas-fir is encouraged by minimizing disturbance.
- Heavier thinning is used to create gaps for underplanting or natural regeneration of tolerant species and to develop shrub cover.
- Snags and down logs are created during treatments if adequate natural decadence does not develop.
- Root rot pockets are selected for the heaviest thinning or group selection with regeneration favoring alder and maple.

After stands reach desirable structure, late-successional forest can continue to develop in moister plant associations without major disturbance for some time. Heavier accumulations of coarse woody debris can be allowed and will help retain moisture on these microsites, particularly with the protection from large-scale fire afforded by the landscape mosaic (Section III. D.). Given the historic importance of stand replacement fires in Moist Forests, strategies for stand regeneration and maintenance of an early successional component will be needed to provide for landscape diversity in the long term. These may be provided by either fire or regeneration harvest, with retention of many live and dead tree components.

Moist-Site Hardwood Stands and Hardwood Stand Components

Two major strategies apply to the moist-site hardwood component of the Moist Douglas-fir community type:

- Allow or facilitate the succession of conifers, particularly to regain a heavier component of cedar which was historically more frequent in areas currently dominated by early-successional hardwood stands.
- Retain a component of hardwoods during thinning of both early- and late-successional stands in order to maintain biological diversity, soil productivity, and fire-resistance.

Planting and substantial vegetation management effort may be required to re-establish redcedar in many areas that currently have low potential for natural regeneration (heavy brush and absence of woody debris that provides regeneration sites for cedar or hemlock). Potential benefits to the ecosystem are high however, as late-successional conifers will develop into long-term habitat. The typical component of bigleaf maple in many moist hardwood stands should be retained or regenerated as it is a longer-lived, late successional midstory hardwood. Although re-establishment of conifers is desired in many hardwood-dominated areas, a component of alder and maple, individually and in patches should also be maintained in suitable microsites throughout Moist Forest areas.

Specific Guidelines for Managing Moist Forests

Stability

Patch level: patches 0.5 to 1 acre in size, stationary over long-term. Stand level: relatively stable overstory cover, increasing age , directional change with continuing development of late-successional components. Landscape (ELU) level: stable or increasing proportion of landscape (gradual site succession occurring at mesic end of gradient with fire suppression in Dry Forests). Reduce large-scale fire hazard (from 1,000-acre scale to perhaps 100- to 500-acre scale) via maintenance of abrupt fuel gradients within a dry-moist patch mosaic.

Age-structure

Develop or maintain mixed-age structure within stands, with recruitment of tolerant midstory. Expand older age classes within and between stands.

Canopy cover

Total canopy cover should be maintained at about 60%, assessed over a minimum area of 5 acres.

Stem density, stocking

Density of trees greater than 4 inches DBH from 150 to 230 trees per acre at maturity.

Species composition

Douglas-fir dominant in overstory. Cedar, hemlock, and maple midstory component.

Species dynamics

Increasing component of cedar, hemlock, and maple in midstory.

Disturbance frequency

Mature forest structure is developed by short-term treatments to accelerate development of large overstory trees, snags, coarse woody debris, and vertical and horizontal canopy diversity. Initial treatments: stocking control required in occasional dense patches of natural regeneration; generally low requirement for precommercial thinning with relatively low numbers of tolerant trees being established in shrubby understory.

As stands reach desired structure, moist areas in dry/moist matrix may be left alone for long periods. At the landscape level, occasional stand replacement disturbances will be needed to maintain some early successional component (> 10%) over the long term. Overstory mortality results from either fire or regeneration harvest, with retention of many live and dead tree components.

Scotch broom strategy

Generally, there is a low hazard of invasion by Scotch broom on moist sites in the interior of conifer forests. Partial canopy retention maintains light levels too low for Scotch broom. Even in larger, management-created clearings, dense cover of native shrubs inhibits Scotch broom establishment.

Overstory/understory patchiness

Increase patch-diversity within stand. Develop higher density tree groups with low understory cover and lower density tree groups with higher shrub, understory tree, and sapling cover at about a 2:1 ratio.

Snags, coarse woody debris, fuels

Protect existing large snags and down logs. Allow natural recruitment of large snags to achieve a minimum of two large snags per acre (≥ 24" DBH, ≥ 20 feet tall) over the long-term. Provide for accumulation of down logs to achieve a minimum of 240 feet of length per acre (≥ 20 inches diameter, ≥ 20 feet in length) over the long term. Where needed, creation of coarse woody debris accompanies timber harvest.

Regeneration and stocking control strategy

Artificial and natural regeneration of tolerant species. Maintain overstory of 30% to 50% until established. Occasional overstory removal in 0.2- to 1-acre patches (with some retention) to maintain vertical canopy diversity and recruitment of young age component in gaps.

Explore opportunities for accomplishing treatments using (1) coordination with military need for poles and (2) new markets and operational techniques to provide economical removal of small trees.

Priority for selection of treatment units

Maintain core areas of large or old stems currently rare in managed forest areas.

At ELU level, short-term priorities for treatment are:

- Thinning overly-dense, young timber in predominantly even-aged areas and initiate structural diversity with variable-density thinning.
- Stands adjacent to high-quality core areas of remnant Historical Dry Forest.
- Maturing stands with large remnant trees and immediate potential for multi-layered structure.

Stand unit

Lay out stand units to include ecotones and accomplish treatments to maintain typical character of ecotones. Maintain or create abrupt fuel gradients at ecotones between Moist and Dry Forests.

Treatment strategies for major silvicultural objectives

Development and maintenance of Moist Forest structure should be encouraged by the following treatments within patches or across stands. The treatments can be applied singly or in combination to accomplish major silvicultural objectives:

- Thin overstory (variable density) in areas of uniform canopy to stimulate regeneration of Douglas-fir and native understory cover (maintain enough canopy cover to inhibit Scotch broom).
- Create new canopy gaps, or expand existing canopy gaps, by removing overstory trees, especially above existing patches of natural conifer regeneration. In stands where natural regeneration is rare or absent, followup quickly with artificial regeneration, before Scotch broom or natural brush can get the upper hand. If dense, natural brush is present, slash the brush, then followup quicly with artificial regeneration.
- Favor existing intermediate-canopy of conifer or maple by selective cutting of individual overstory trees.
- Retain and protect existing mature forest structure including large live Douglas-fir, both sound and decadent, any existing cedar, hemlock, or maple component and large snags, or down wood.
- Maintain undisturbed patches of well-spaced overstory Douglas-fir to develop large but branch-free boles and sparse, shaded understory.
- Thin dense patches of saplings to maintain low stem density and increase growth of residual sapings, and to maintain some understory shrub cover, maintain existing species diversity during selection of leave trees.
- Select root-rot pockets for heaviest thinning or group selection and favor regeneration of alder, maple, cedar, or shrub cover if necessary to avoid regeneration of Douglas-fir in infected areas.
- Regenerate early successional patches in larger areas using shelterwood harvests and long-term retention of residual trees and snags (two-storied stands), followed by artificial regeneration, if needed. Occasional occurrence in landscape units historically subject to stand replacement fires across contiguous Dry/Moist Forest matrix.
- At maturity (existing or in the future) protect or maintain late-successional conditions in Moist Forest; natural or managed disturbances produce small gaps.
- Explore new techniques for harvesting and yarding small material with minimal soil disturbance.

3. WHITE OAK WOODLANDS

A continuing strategy is to maintain intact but declining Oak Woodlands by removing or preventing further encroachment of Douglas-fir. Invasion of Scotch broom and exotic grasses is a major problem in many areas with oak. Further efforts to restore stand structure and native understory vegetation in degraded oak communities will be made on an experimental basis, employing prescribed burning, brush removal, and planting of native understory species. Habitat requirements of western gray squirrels will be considered in any manipulation of overstory composition and structure in Oak Woodlands.

In combination, prescribed fire and silvicultural treatments emulate fire disturbances that favored oak in the historical landscape. Silvicultural strategies to maintain and restore Oak Woodlands employ selective cutting or thinning of Douglas-fir within current woodlands. In some cases, selective removal of Douglas-fir can also be extended to adjacent young colonizing forests to favor remnant oaks and oak saplings. Removal of invading Douglas-fir can often be accomplished by integrating oak areas within Douglas-fir stand management units (as many oak stands are

currently). The ongoing program of prescribed burning on prairies can also maintain Oak Woodlands as fires enter oak areas at prairie margins.

The original delineation of Oak Woodlands at Fort Lewis (Kessler 1990, Macklin and Thompson 1992) has been updated with the more detailed survey of Chappell (2003). This is being combined with lessons learned in initial restoration efforts (see ELU strategies, Sec. III.D) to develop a comprehensive Oak Woodland Management Plan for Fort Lewis, scheduled for completion in fall 2001.

4. PONDEROSA PINE SAVANNAS

Within forested areas, the pine component should be favored wherever it occurs, using selective cutting or thinning of adjacent Douglas-fir (see Appendix F). This is quite compatible with the uneven-aged management strategy for Dry Forest. This approach will maintain a pine component as part of typical Dry Forest structure, but will not encourage regeneration of pine, which is favored by high-light (open) conditions and the ash seedbeds left behind by recent fire.

More active restoration and maintenance of open pine savanna or woodland conditions is underway in and adjacent to the Bower Woods RNA (see strategies by ELU's, Sec. III.D). Treatments include a combination of commercial harvest, precommercial slashing, and girdling of overstory and understory Douglas-fir, mowing Scotch broom, prescribed fire, and planting pine seedlings (Foster 1997).

Specific Guidelines for Managing Ponderosa Pine Woodlands

Overstory/understory patchiness

Increase patch-diversity within stands. In stands dominated by pine, create scattered tree clumps and individual trees at a wide spacing that emulates the savanna-like structure of pre-European, Eastside pine forests. In stands with a substantial component of Douglas-fir, create denser, woodland structure, with some residual fir. Shrub layer very patchy, with low cover, in both kinds of stands.

Snags, coarse woody debris,fuels

Since these ecosystems naturally were subject to frequent fire, levels of snags and logs were quite low. Therefore, dead wood management consists simply of protecting existing large snags and logs, and allowing natural recruitment of additional snags and logs.

Regeneration and stocking control strategy

Preference is for natural regeneration of ponderosa pine following restoration treatments. If natural regeneration is minimal or absent, plant pine grown from seed collected on site.

Priority for selection of treatment units

Short-term priorities for treatment are:

- Stands where pine is the major canopy dominant.
- Especially high priority are pine-dominated stands where the understory includes a substantial component of native prairie species.

Stand unit

Create gradients between open pine savanna with native prairie understory and closed Douglas-fir forest with scattered overstory pine.

Treatment strategies for major silvicultural objectives

Development and maintenance of a woodland or savanna structure should be encouraged by the following treatments within patches or across stands. The treatments can be applied singly or in combination to accomplish major silvicultural objectives:

- Remove all overstory Douglas-fir, except for wildlife trees, in stands slated to become savannas. In stands slated to become woodlands, remove majority of overstory Douglas-fir.

- Slash all understory Douglas-fir in stands slated to become savannas. In stands slated to become woodlands, leave some understory Douglas-fir.
- Mow or burn Scotch broom in all stands scheduled for restoration.
- Conduct prescribed fire within 1-2 year following completion of timber harvest and mowing. Repeat burning at 3- to 5-year intervals.
- As needed, remow Scotch broom regeneration from seed or root crowns prior to seed set. Objective is to exhaust the soil seed bank.
- If natural regeneration is scarce, plant pine seedlings grown from seed collected from pine at Fort Lewis.
- Thin selected pine trees, where necessary, to reach overstory and understory densities appropriate to woodland or savanna structure. This should be done following prescribed fire, which may often kill some of the pine.

5. WETLAND/FLOODPLAIN FORESTS

The largest Wetland/Floodplain Forests (cottonwood, willow, and Oregon ash) occur in the Nisqually Floodplain RNA, where natural disturbance processes continue to maintain the ecosystem. Patches of wetland forest scattered elsewhere throughout the Fort will continue to be maintained and protected during any management activity in adjacent upland forest (Sec. III.D and IV.L).

6. PRAIRIES

Although forest management activity does not directly affect the 20,435 acres of prairie, further encroachment of Douglas-fir will be prevented through prescribed burning and maintenance of ecotones between forests, woodlands, and prairie. Peripheral patches of Douglas-fir may be removed in efforts to restore or maintain prairies. Fort Lewis is currently preparing a Prairie Management Plan that will guide management activities on prairies.

D. LANDSCAPE MANAGEMENT STRATEGIES

1. GENERAL LANDSCAPE STRATEGIES

The three strategic goals stated in Section III.A.1 are integrated in complementary strategies to develop a landscape pattern that emulates many attributes of the historical landscape. Some calculated departures from historic landscape patterns are also needed in light of the new disturbance regime and the increased extent of contiguous forest.

A major challenge arises from the desire to develop mature forest ecosystems in a fire-suppressed environment, while preventing the accumulation of fuel hazards conducive to large-scale, catastrophic fires. This risk is exacerbated by the fact that most ignitions are the result of military training. The general strategy for meeting this challenge is to maintain a landscape pattern of vegetation structure that produces a patchy distribution of fuels. Two approaches to this strategy will be utilized:

- **Open Mosaic** - Maintain and restore the large-scale pattern of interweaving prairies, woodlands, and forests characteristic of areas dominated by outwash (Group I soils). Management emulates the historical, fire-driven landscape in appropriate areas, with the use of prescribed fire on prairies and their margins, and with periodic patchy disturbance in associated, Dry Forest types.

- **Closed Mosaic** - Maintain low or discontinuous fuel levels in larger contiguous areas of both Dry Forest and Dry/Moist Forest matrix, characteristic of forested hills (Group II and III soils). Accomplish this by developing or maintaining patchy, mature forest structure in Dry Forests, emulating the native dry-forest structure that develops under frequent fires of variable intensity. Heavier accumulation of fuels (coarse woody debris) in Moist Forests or moist microsites will retain moisture and be relatively resistant to light ground fires in adjacent Dry Forests.

With maintenance of these landscape conditions, accidental military ignitions should continue to produce frequent but small fires of variable intensity. These fires can help maintain the landscape mosaic and some fire-related processes in the absence of catastrophic conflagrations.

Of course, emulation of historical patterns for management of fire hazards is complementary to strategies oriented towards native biodiversity, e.g., maintenance and restoration of ponderosa pine

savanna, oak woodlands, and native prairies, as well as other distinct forest types and successional stages. In general, multiple community types are often integrated within current stand units, typically under a "Conifer" management classification (Appendix A-2). A practical strategy for maintaining the landscape mosaic is to continue (or increase) this integration of types and ecotones within management units. This facilitates removal of trees to maintain open community types adjacent to managed forests, and it provides for continuity of treatments to maintain characteristic transitions between community types, including:

- Abrupt ecotones and steep moisture gradients between Dry Forests and Historical Moist Forests or forested wetlands.
- Both gradual and abrupt ecotones between prairie, savanna, woodland, and Dry Forests.

With respect to late-successional forest habitat, the predominance of Dry Forests provides a fortuitous opportunity to maintain a large component of mature forest in a condition relatively resistant to severe fire. Under pre-settlement conditions, Dry Forest sites in the interiors of contiguous forest areas probably developed high fire hazards. While departing somewhat from these historical conditions, management treatments emulating a more frequent fire regime on interior forest sites can maintain stand structure within the general range of variability of natural Dry Forest types. This calculated departure mitigates the hazards inherent in the development of mature forest across today's expanded, contiguous forest acreage.

Although the dearth of older forests places a high priority on treatments for developing mature forest at Fort Lewis, maintenance of some early-successional components will be needed in the long term. Current guidelines for management of the northern spotted owl indicate a minimum desired condition of 60 percent of the landscape in mature forest stages, which suggests that a significant early-successional component can be maintained with satisfactory development of older forest. In order to maintain a balanced landscape, policies or guidelines for the appropriate amount of early-successional forest should be developed. These could be based, in part, on the habitat needs of browsing mammals, such as deer, and of those species of accipiters which require younger forests. Accidental fires from military ignitions may provide some stand-replacing disturbances over the long-term. If this does not occur, regeneration harvesting with some retention of live and dead tree components should be considered to maintain early-successional forest habitat over the long-term.

Specific application and variation of landscape-level strategies within Ecological Landscape Units is described below, based on current conditions in each ELU. Conditions in each ELU were first summarized by Management Classifications developed from the stand ages, Management Unit Categories, and other land-management designations ascribed to each of **734 delineated stands** in the Forestry Stands Database (Appendix A-2, Appendix D-1 data on file with theForestry Program). Opportunities for treatment, and approximate acreages available for primary silvicultural objectives, are then discussed, based on the distribution of community types and structural attributes *roughly estimated* from independent samples or studies.

2. NORTH-CENTRAL ELU

Overall Strategy

The overall strategy for this landscape unit is to maintain the coarse-grained mosaic of distinct landscape subunits, emphasizing different community-type composition and conditions within each subunit. A key feature at the landscape level is the protection and maintenance of forest areas that provide connectivity with the other ELU's. The separation and isolation of forested blocks, along with the occurrence of open-landscape mosaics within subunits, maintains a low hazard of large-scale fire across the NC ELU as a whole. However, the high potential for stand-replacement fires

within several large forest areas should be addressed with emulation of frequent-fire disturbance regimes to maintain appropriate Dry Forest structure.

Major silvicultural objectives recommended for the diverse conditions in the NC ELU are summarized below, with estimates of total available acreage:

- Initiate structural diversity and accelerate development of mature forest character in young, even-aged forests (about 7,350 acres in this condition).
- Enhance existing mature forest structure in substantial areas of young stands containing older residual trees (about 4,200 acres) and in some older stands (1,160 acres).
- Within stands included under the major objectives above, maintain existing Oak Woodlands in stand units currently classed as Conifer (about 1,100 acres) and retain and enhance residual pine and oak components in Colonization Dry Forests (about 800 acres).
- Prevent overstocking and initiate desirable overstory and understory patterns in regenerating conifer stands (about 3,400 acres).
- Restore and protect ponderosa pine forest and savanna within RNA's (about 880 acres).
- Protect unmanaged forests (totaling about 5,000 acres).

Conifer Forest

Strategies for Dry Forests predominate in all age-classes across the ELU, which is about 80 percent Dry Forest, with some variations of the typical approach being applicable, depending on conditions in each subunit. Substantial areas of forest suitable for initiation and enhancement of mature forest structure occur in an Open Mosaic within the south-central Argonne/Marne subunit. Strategies for the predominant Dry Forest here include uneven-aged patch management, along with strategies to retain residual oak components in Colonization Dry Forests and maintain adjacent Oak Woodlands.

The Central Impact Area subunit contains remnants of an Open Mosaic. However, the forest here is dominated by a large block of dense, unmanaged forest in the center of the area. Pine restoration treatments in the Bower Woods RNA are a high priority, affecting about 650 acres of the Central Impact Area and adjacent portions of Training Areas 6, 10, and 12. This open pine type and adjacent grasslands (with some pines) isolate the dense forest from other forests in the subunit, though some connectivity with the NE ELU is provided by forests in the northeastern part of the subunit.

Dry Forest strategies for enhancing existing mature forest structure can be centered on old Douglas-fir stands within the pine restoration area (about 137 acres). Outlying forested hills in the CIA subunit (Cherry Hill and Kicker Hill to the south, Murray Creek area to the north) contain residual old trees and a multi-age-class potential that provide a basis for enhancing and expanding core attributes of mature forest.

In the North Fort subunit, young forest areas often contain older residual trees, occurring in a unique Open Mosaic landscape comprised of large marshes and lakes, Oak Woodlands, and the developed grounds of the cantonment area. Although these forests are somewhat isolated by the cantonment area and I-5, there is some connectivity with undeveloped areas outside the Fort boundary to the west.

A Closed Mosaic strategy applies to larger contiguous forest areas, forming a perimeter from the Marne forest around to the northwest slope of the Argonne block. Although Dry Forests predominate, Douglas-fir/salal plant associations grade into western hemlock/salal associations on relatively moist north slopes. Natural regeneration of Douglas-fir may be difficult on dry sites in the interior forests away from woodland edges. Salal, in particular, may inhibit regeneration under partial shade. Thus, while typical uneven-aged strategies should be initiated in Dry Forests, with supplemental artificial regeneration in some cases, even-aged regeneration methods and two-storied stands may be appropriate for forest structure in some stands. This is applicable where adjacent, Open Mosaic communities or the relative isolation of the forested block reduce concerns about large-scale fire hazard. Madrone occurs as a significant intermediate canopy component, providing species diversity that can be encouraged via thinning and group selection of Douglas-fir.

The Nisqually River and Muck Creek corridors provide rare escarpments and alluvial features, with significant areas of older Historical Moist Forest reserved inside the RNA's and the South Impact Area. Historical Moist Forests also occur within scenic buffers in the Nisqually River corridor farther upriver near Yelm. While some of these Historical Moist Forests are suitable for strategies to initiate structure in young stands, a significant component of older trees and hardwoods should be retained as core components. A large area suitable for initiation of mature forest structure occurs in a contiguous block of young, even-aged timber that stretches from the Nisqually River canyon north to the upland forest around Lewis Lake. Most of this forest can be managed with Dry Forest strategies for uneven-aged or two-storied structure within contiguous forest.

Ponderosa Pine Woodlands

The Central Impact Area subunit contains the best remaining ponderosa pine communities, concentrated in the Bower Woods RNA. Including these remnant stands as a core area, The Nature Conservancy recommends restoring pine communities on about 1,100 acres over the long-term, including about 880 acres within the forested portion of the Central Impact Area.

Most ponderosa pine outside of the RNA occurs in scattered clumps with grass and brush in non-forest areas surrounding the forested impact area. The extent and condition of these areas has been studied, and ecological restoration is on-going on 454 acres (Foster 1997).

Oak Woodlands

Existing Oak Woodlands in the NC ELU should be maintained on about 1,100 acres currently classified as conifer forest and about 500 acres classified as non-forest. Oak Woodlands are a major component of the Open Mosaic within the central Argonne/Marne subunit and within the Central Impact Area subunit. Oak Woodlands and remnant oak components can be maintained in these areas, with the general strategy for an Open Mosaic, by incorporating oak areas and oak/forest ecotones within management units.

Oak in the NC ELU also occurs quite often as narrow woodland strips between prairie and forest at the base of forested hills (Closed Mosaic landscapes). These strip woodlands should be maintained with continued application of prescribed fire at prairie margins and with specific prescriptions to prevent encroachment of Douglas-fir. Oak groves are also scattered in cantonment areas, and should continue to be maintained on the developed grounds.

Wetlands

Most of the forested wetlands (about 740 acres) are concentrated in the Nisqually River/Muck Creek corridor, primarily reserved within the RNA's. Management emphasizes forest structure to favor wildlife (e.g., snags and nesting structures) in forests associated with large marshes and lakes, particularly common on North Fort (Section IV.D.1). Actual wetland areas will be protected during treatment of adjacent forest areas, as described in Section IV.L.1.

Reserves and Core Areas

The unmanaged forest block in the Central Impact Area provides a unique reserve of maturing Dry Forest (about 2,000 acres). This relatively unmanaged forest has several outstanding, old-growth components associated with islands of Historical Dry Forest, scattered within a dense matrix of Colonization Dry Forest. Presently, fire hazards are accumulating in these forests, though the surrounding Open Mosaic landscape isolates this hazard within the Fort Lewis landscape. Maintenance of an extensive system of fire roads offers some protection and access. This reserve provides important opportunities for:

- Observation of long-term forest development in Colonization Dry Forests.
- Baseline measurements of soil properties for comparison with managed Dry Forest areas.

The 220-year-old old forest along the Puget Sound bluff is a valuable, unmanaged area, serving as a Conservation Reserve of some significance. Adjacent stands on top of the bluff should be treated with consideration for their connectivity to the older forest area. Urban development (North Fort Lewis) and I-5 isolate this subunit from other forested subunits.

The three RNA's occurring in the NC ELU are Nisqually Floodplain (1,300 acres), Ellsworth Woods (410 acres), and Bower Woods (1,620 acres within the NC). The Nisqually Floodplain RNA provides a conservation reserve containing high quality examples of mature riparian forests and backwater areas (Washington Natural Heritage Program Element "low elevation stream and riparian system"). Bald eagles also use this area for wintering habitat. Ellsworth Woods RNA contains mature and old-growth communities representing primarily Dry Forest types, but also some Moist Forest communities, together with a low-elevation stream and riparian system. Small-flowered trillium is also found here. The 400-year-old age-class of Douglas-fir in the center of this RNA is hypothesized to represent a late-successional stage of Colonization Dry Forests that escape stand-replacement fires for a long time. Bower Woods RNA protects ponderosa pine and Oregon white oak communities, along with western gray squirrels and the white-top aster.

3. NORTHEAST ELU

Overall Strategy

The overall strategy for this landscape is to maintain the characteristic Open Mosaic pattern of forest, wetland, woodland, and prairie throughout the ELU. Although historic forest patches within this mosaic were generally not subject to large-scale, stand-replacement fires, the large post-settlement increase in contiguous forest area produces the potential for catastrophic fire. Past management has maintained low fuels with periodic, uniform thinning throughout these areas. Future management will continue to prevent severe fire hazards in contiguous forest and develop a maturing forest component in an otherwise stable landscape mosaic. Much of the landscape in this ELU will be maintained with frequent disturbance of grassland, woodland, and Dry Forest, emulating historic disturbance processes in the Open Mosaic.

Major silvicultural objectives recommended for the current conditions in the NE are summarized below, with estimates of the total available acreage:

- Initiate structural diversity and accelerate development of mature forest character in young, even-aged stands (about 6,700 acres).
- Enhance the substantial, existing mature forest structure in older stands (about 3,200 acres, 85- to 125-years-old) and in young stands with older residual trees (about 2,800 acres).
- Maintain existing Oak Woodlands in stand units currently classed as Conifer (about 1,100 acres) and retain and enhance residual pine and oak components in young Colonization Dry Forests (about 1,900 acres).
- Develop overstory trees and maintain low fuels, military vehicle access, and future options in even-aged Colonization Dry Forests (about 2,600 acres)
- Prevent overstocking and initiate desirable overstory and understory patterns in regenerating conifer stands (about 2,900 acres).

Conifer Forest

Strategies applicable to Dry Forest communities predominate in both young and old stands, and should be integrated with treatments of woodland and prairie to maintain the Open Mosaic character of the NE ELU. There is much opportunity for enhancing existing multi-age structure and mature forest components using typical Dry Forest strategies within both older stands and younger stands with old residual trees. Natural regeneration of Douglas-fir is quite abundant in partial openings, facilitating uneven-aged patch management within many stands. Older areas of Colonization Dry Forest provide about half of the existing mature forest structure, often deriving from a few older Douglas-fir with multiple age classes of progeny that now form a closed canopy.

Infrequent Moist Forest types should be managed with the typical strategies for this type, depending on current structural conditions. A few larger blocks of Historical Dry Forest contain significant areas of Moist Forest that should be managed for late-successional structure while maintaining abrupt gradients in fuel loading between Moist and Dry Forests (Closed Mosaic strategy). Moist Forests are most often associated with large wetlands complexes. There will be increased emphasis on certain wildlife habitat elements in these areas due to the proximity of

wetlands, primarily in the form of accelerating the formation of natural cavities within forested habitats adjacent to wetlands.

Treatments to initiate structural canopy diversity should be considered for about one-third of the even-aged young stands (45- to 85-years-old), with the priority placed on areas of Historical Dry Forest containing characteristic forest understory elements. About two-thirds of the even-aged, young stands are Colonization Dry Forests that should be managed conservatively or experimentally. There is a priority for restoration of residual and declining woodland components in
colonizing forests in order to enhance the remaining Open Mosaic character of the ELU. Other areas of relatively uniform Colonization Dry Forest should be conservatively managed to develop overstory trees, while maintaining low fuels, military vehicle access, and future options.

Ponderosa Pine Woodlands

About 780 acres currently classed as conifer forest contain significant pine components, generally in mixture with dominant Douglas-fir, sometimes with residual oak. Within forested areas, the pine component should be favored wherever it occurs by selective cutting of adjacent Douglas-fir. Preliminary recommendations by The Nature Conservancy called for restoration of about 77 acres of open ponderosa pine/Douglas-fir forest and 42 acres of ponderosa pine/white oak woodland in the NE ELU (Units 2 and 3 of the Bower Woods Ponderosa Pine RNA). Ponderosa pine also occurs in scattered clumps with grass and brush in non-forest areas of the ELU. Restoration of the acres identified by The Nature Conservancy is currently underway (Foster 1997).

Oak Woodlands

Existing Oak Woodlands in the NE should be maintained on about 1,100 acres currently classified as conifer forest and 200 acres classified as non-forest. Colonizing forests with residual oak components are common, often closely associated with both intact and declining Oak Woodlands. This facilitates a strategy for both maintenance and restoration of oak types using incremental treatments to control Douglas-fir, proceeding into forested areas with remnant oak trees and saplings.

Wetlands

Wetlands are a major feature of the landscape mosaic, concentrated in the series of marshes in the western half of the ELU. Forested wetlands (380 acres) are often adjacent to valuable mature forest components and intact woodlands, occurring together around major wetland depressions. Management should focus on protection and maintenance of these associated types and their ecotones around wetlands. Management to favor wildlife may emphasize snags and nesting structure (Section IV.D.1). The actual wetland area will be protected during treatment of adjacent forest areas, as described in Section IV.L.1.

Reserves and Core Areas

Two units of the Bower Woods RNA protect ponderosa pine and Oregon white oak-conifer mosaic communities within this ELU. Western gray squirrels may utilize these pine and oak habitats. Thirteenth Division RNA (234 acres) contains Idaho fescue-Puget balsamroot grassland, a small area of high quality riparian forest (29 acres) and a patch of Oak Woodland (19 acres). Rare plants protected in the RNA include the white-top aster (prairies) and small-flowered trillium (riparian woodlands).

More than half of the older stands are older than 100 years and may contain suitable core areas, providing the best examples of existing mature forest in the ELU. These are associated with both Dry and Moist Forest areas near wetlands and certain topographic breaks. A more complete identification and mapping of areas with significant mature forest elements should be developed and treatments in adjacent forests should be prioritized to enhance and expand desirable structure around these areas.

4. RAINIER TRAINING AREA ELU

Overall Strategy

The overall landscape strategy for the RTA emphasizes development of mature forest in a relatively stable mosaic of Dry and Moist community types within the large, contiguous forested area. The RTA has much potential for catastrophic fires due to the accumulation of fuels across the predominant, Closed Mosaic forest matrix. This risk will be minimized by the development of open, mature-forest structure on dry sites, with accumulation of heavier woody debris in moist depressions within the small-scale mosaic of moist and dry forest patches. Small but frequent, forested wetlands and a widespread component of moist-site hardwoods will be maintained as characteristic elements of biodiversity within the forest. Also, a significant part of the southern RTA contains inclusions of prairie, woodland, and Dry Forest that will continue to be maintained with an Open Mosaic landscape strategy. With the predominance of young, even-aged stands in the RTA, the primary silvicultural objective is to initiate structural diversity and enhance mature forest character using appropriate treatments within both conifer and hardwood forest types. Major silvicultural objectives recommended for the current conditions in the RTA are summarized below:

- Initiate structural diversity and accelerate development of mature forest character in young, even-aged forests (about 9,350 acres).
- Enhance existing mature forest structure in occasional areas of young stands containing older residual trees (about 900 acres) and in predominantly older stands (about 50 acres).
- Within stands included under the major objectives above, maintain existing Oak Woodlands in stand units currently classified as conifer (about 600 acres) and retain and enhance residual oak components in Colonization Dry Forests (about 450 acres).
- Prevent overstocking and initiate desirable overstory and understory patterns in regenerating conifer stands (about 1,580 acres).
- Facilitate succession to cedar, hemlock, and maple in stands currently dominated by short-lived alder (1,800 acres).

Conifer Forest

Approximately 55 percent of the conifer forest matrix should be treated as Moist Forest and the remainder as Dry Forest. Throughout both Dry and Moist Forest community types, conditions are quite deficient in age-class diversity and remnant large trees or dead wood. Limited opportunities for enhancing existing mature forest structure occur on a small portion of young stands with older residuals. Thus, a large area of 45- to 85-year-old Douglas-fir stands should be considered for the primary objective of initiating or enhancing structural diversity in young, even-aged stands.

Low fuels should be maintained by continued selective harvesting and thinning in the Dry Forest part of the forest matrix, employing uneven-aged patch techniques where possible. Greater accumulations of dead wood can be developed in moist microsites, particularly large down wood. The low priority for military vehicle access allows for undisturbed development of down wood and understory structure on most sites in the RTA.

Tree-marking decisions should be sensitive to the substantial microsite heterogeneity in the RTA. Silvicultural prescriptions should employ combination cuts and variable-density thinnings in order to apply the typical strategies on Dry and Moist sites respectively. Design and layout of treatments should be similar to the variable-density thinnings used previously by the Forestry Program and by the Forest Ecosystems Study (Carey et al. 1999), except that allocation of treatments within stands should be more dependent on microsite conditions.

Dry Forests in the predominant, Closed Mosaic area are characterized by relatively low rates of natural regeneration in partial openings and potentially high levels of vegetative competition. This can be mitigated in many stands with underplanting of tolerant species underneath existing canopies, and of both shade-tolerant and –intolerant species in natural and deliberately created openings. However, due to the often well-developed shrub layers in these stands, and the absence of underburns, mechanical brush treatment may be necessary for sucessful tree establishment.

In the Open Mosaic landscape in the southern RTA, regeneration of Douglas-fir is more abundant, which facilitates uneven-aged patch methods, though the hazard of Scotch broom invasion must also be considered here.

Stand-replacement fires were a characteristic natural disturbance in the RTA. Accidental fires from military ignitions may provide some stand-replacing disturbances over the long-term. If this does not occur, regeneration harvesting with some retention of live and dead tree components should be considered to maintain early-successional forest habitat within the RTA. The current component of early-successional habitat may be adequate for now, particularly given the predominance of regenerating clearcuts surrounding the RTA.

Moist-Site Hardwoods

About 1,800 acres of 45- to 65-year-old alder/maple stands provide the only major component of

hardwood-dominated stands on the Fort. Since the dominant alder component is short-lived (declining after about 75 years), management should favor existing patches of Douglas-fir and facilitate long-term succession to western redcedar and hemlock (Sec. III.C.2). The present component of bigleaf maple should be maintained in both hardwood and conifer stands because it is a long-lived, tolerant species, immediately available for enhancement of structural diversity.

The moist hardwood component is a characteristic element of biodiversity that should be maintained in the RTA. Hardwoods facilitate rapid accumulation of soil organic matter, contribute to nutrient cycling (including enhancement of soil nitrogen by the roots of alder), and impart a degree of fire resistance to the landscape. Due to the high incidence of soil disturbance associated with early logging, the current amount of alder represents a large increase over the amount found in historical ecosystems. Thus, a reduced but continuing component of alder is desirable in Moist Forest ecosystems.

Relatively high levels of wind-disseminated alder seed produce adequate or excessive regeneration of alder with soil disturbance. Planting of alder on sites infected with *Phellinus* is appropriate on moist sites, particularly in large openings, to facilitate development of forest cover that is not susceptible to the root disease. Stocking control treatments in regenerating forests should retain some naturally regenerated alder in appropriate microenvironments. Adequate (not excessive) amounts of alder appear to be present in newly regenerated management units.

Oak Woodlands

Most of the Oak Woodlands in the RTA are mapped in areas currently delineated as conifer stands available for management. Thus, a small portion of the acreage currently classed as young conifer should be maintained as oak woodland. Continuing encroachment of Douglas-fir will be prevented, generally in conjunction with treatments in adjacent conifer forest. Ecological restoration began several years ago in Oak Woodlands surrounding Upper Weir, Lower Weir, and Johnson Prairies (reference). Treatments have included cutting mature and young Douglas-fir, mowing Scotch broom, and prescribed fire.

Douglas-fir has colonized about 750 acres of historic woodlands and prairie between Weir and Johnson Prairies, an area currently delineated as a secondary boundary for the Weir Prairie RNA. This forest provides a good opportunity for experimenting with woodland restoration in conjunction with application of the uneven-aged patch strategy for Dry Forests. Since the current component of oak in the RTA exceeds estimates of the historic component, there is a relatively low priority for reclaiming woodland within the remaining acres of colonizing Douglas-fir forest. Eighty-year-old stands of Douglas-fir in some older, colonized woodlands contain residual Douglas-fir parent trees, providing about half of the existing residual age structure.

Wetlands

Small forested wetlands are well distributed throughout the RTA, occurring within Historical Moist Forest hardwood stands or on the fringe of larger, brushy wetlands. Long-term succession to a mixed conifer overstory will provide a more permanent forest canopy around forested wetlands in Moist Forest hardwood areas. Management to favor wildlife may emphasize snags and nesting

structure in stands adjacent to wetlands (Section IV.D.1). The actual wetland area will be protected during treatment of adjacent forest areas, as described in Section IV.L.1.

Reserves and Core areas

About 140 acres of Dry Forest and 60 acres of Oak Woodland occur in the Weir Prairie RNA. The entire Weir Prairie system is contained within the RNA, including three alluvial terraces. Idaho fescue-Puget balsamroot grassland and Oregon white oak woodland vegetation communities are protected, as are several populations of the white-top aster. Treatments in the RNA will focus on protection and restoration of natural woodland and Dry Forest characteristics. Results of these efforts should be monitored and incorporated into the adaptive management process for Dry Forest and woodland types in the RTA.

Although very little reserved forest or remnant core components have been identified or delineated in the RTA, field observations indicate there are some unmapped areas containing significant older residual elements and structural diversity. These should be located and mapped as core areas. Existing structural diversity should be preserved and enhanced when found, utilizing the flexibility and judgment of foresters in the field.

Leased Land

There are 1,626 acres of leased lands, owned by the State of Washington, Thurston County, and Weyerhaeuser Corp., in the RTA. Most of this land was clearcut during the 1990's, so the individual land parcels have become deforested "islands" in a sea of maturing forest. The Weyerhaeuser lands (1,200 acres) will become Army property in approximately ten years' time, at which time they can come under active management by the Forestry Program. In addition, ?? acres of Thurston County land will become Army property in the next year or so, as part of a three-way land swap between Fort Lewis, the Nisqually Tribe, and the Bonneville Power Association.

IV. MANAGEMENT STRATEGIES FOR SPECIFIC GOALS

This section provides qualitative statements of management goals with respect to specific resources or system attributes, developed from the Guiding Principles (see Preface). Strategies for achieving specific goals are listed after each goal, with reference to general ecosystem management strategies (coarse filter approach) and with further descriptions of specific measures as needed (fine filter approach).

A. MILITARY TRAINING FOREST

1. PROVIDE A VARIETY OF FOREST TYPES SUITABLE FOR MILITARY TRAINING

Troop training exercises, on foot and in vehicles, are regularly conducted in the installation's forests. The varying degrees of concealment offered by individual forest stands provide a diversity of training conditions. The degree of concealment is affected by site productivity (dry vs. moist) and silvicultural manipulation. The typical light thinnings in most forest stands maintain adequate canopy cover and brush for troop concealment, yet facilitate troop and vehicle movement by reducing tree density. Prescribed burning in oak, pine, and Douglas-fir savannas and woodlands reduces brush and facilitates military training on up to several thousand acres per year.
Some treatments should be designed to meet special requirements for certain training areas, as needed. An example is the ROTC "training lanes" kept free of large down logs within stands in the south-central portion of the Northeast ELU. The Forestry Program will continue to coordinate closely with military trainers to make sure forest management activities do not negatively affect training and, preferably, enhance training.

A special consideration is the ongoing transformation of the two brigades (one heavy, one light) at Fort Lewis into Interim Brigade Combat Teams (IBCTs or medium brigades). The changes in vehicles (i.e., tracked vehicles such as tanks replaced by eight-wheeled, light-armored vehicles) and tactics that accompany this transformation may affect training needs in forested areas. The Forestry Program will be involved in the preparation of the Environmental Impact Statement for the IBCTs. Any changes in forest management to accompany transformation will be documented in the EIS and the Fort Lewis INRMP.

B. HEALTHY FOREST ECOSYSTEMS

1. PROTECT THE FOREST FROM CATASTROPHIC FIRE

Prevention of catastrophic fire hazards is one of the major strategic goals developed under the this Strategy (Section III.A). Forestry staff will continue to protect forests from wildfire, using prevention, detection, and suppression measures, along with careful prescribed burning. Periodic treatments to reduce fuels are required in a fire-suppressed system to prevent accumulation of fuels/hazard to levels outside the range of suppression capabilities. The general strategy for this is to maintain the landscape pattern of variable, discontinuous fuels (Section III. D). This is particularly important in the extensive areas of Dry and Colonization Dry Forest that have historically been maintained at low fuel levels by frequent, low-intensity fires or thinnings.

2. MAINTAIN OR ENHANCE THE HEALTH, RESILIENCE, AND PRODUCTIVITY OF THE FOREST

The overall strategy for maintaining biological diversity and appropriate ecosystem patterns and processes should also maintain healthy, resilient, and productive forests. Specific measures should also be taken to ensure that forestry practices maintain health and productivity, including:

- Maintenance of soil organic matter and soil nutrients:
  - sustain inputs of litter and woody debris
  - maintain component of soil-building trees and shrubs (alder, maple, cedar)

- Careful design and scheduling of forest operations to prevent excessive soil compaction
  - use of special equipment
  - designation of skid trail locations or yarding corridors, if necessary
- Location of concentrated equipment operation in areas already compacted:
  - old roads and landings
- Rehabilitation of heavily impacted areas, where possible.

3. MAINTAIN ENDEMIC LEVELS OF INSECTS AND PATHOGENS AND PREVENT EPIDEMIC INFESTATIONS

Specific silvicultural practices that will help to maintain healthy forest conditions, with endemic levels of insects and pathogens, include:

- Thinning in overly dense stands to avoid competitive stress.
- Planting species and genotypes of trees that are locally adapted.
- Designing thinnings to minimize windthrow.
- Sanitation thinning in *Phellinus* root-rot centers, followed by planting of tree species resistant to root rot (alder, western white pine).

Phellinus root rot is the most noticeable pathogen causing mortality in Fort Lewis' forests. While excessive amounts of the disease may be considered unhealthy, the minor but widespread incidence of *Phellinus* that occurs across the Fort Lewis landscape creates multiple gaps in forest canopies and creates large snags and logs through tree mortality. Although these endemic levels should be maintained, net increases in *Phellinus* should be prevented by allowing or encouraging development of non-susceptible species in root rot centers, along with some sanitation thinning to reduce spread to healthy trees. In extreme cases, where *Phellinus* is decimating entire stands, removal of all live trees, snags, and stumps from infection centers, followed by planting of resistant species, may be warranted.

4. PROTECT THE NATIVE FOREST FROM INVASION BY EXOTIC PLANT AND ANIMAL SPECIES

Strategies for silvicultural prevention and control of Scotch broom in forests are discussed in Section III.D. Soil disturbance, a major factor favoring exotic species, should be minimized during silvicultural treatments, particularly at woodland-forest ecotones. Solutions to existing problems with Scotch broom in forest openings will continue to be pursued. In conjunction with efforts to restore native plant communities, application and testing of control treatments should continue, including:

- Continued attempts to determine optimal conditions for achieving control with repeated burning of Scotch broom patches.
- Biological controls, including re-establishment of native communities resistant to invasion.
- Chemical controls.
- Mechanical controls, including pulling or cutting.

Maintenance of healthy forests also depends on continued detection and monitoring of forest damage and threats to forest health (due to military training, fire, disease, insects, wind, and exotic species). Locations of problem areas will be mapped and monitored by ENRD staff. The Army's Land Condition Trend Analysis (LCTA) component of the Integrated Training Area Management (ITAM) program will also aid in this process.

C. BIODIVERSITY

1. MAINTAIN AND ENHANCE BIOLOGICAL DIVERSITY THROUGHOUT THE FORT AT VARIOUS SCALES OF RESOLUTION

Maintenance and restoration of native biological diversity and unique plant communities is a major strategic goal addressed in detail under the ecosystem management strategies (Section III.A). Specific recommendations for maintaining biodiversity include:

- Identify, protect, and maintain special forest and non-forest habitats or components, including Pacific yew, native grasslands, forested wetlands of Oregon ash, groves of trembling aspen, and other special plant associations.
- Implement prescriptions to maintain or restore individuals, components, and stands of ponderosa pine and Oregon white oak within or marginal to Colonization Dry Forests.
- Retain residual Douglas-fir trees when stands are harvested. Residuals are large, old trees leftover from the previous stand or that formerly grew as isolated trees on prairie that has been colonized by forest. They are future large snags and logs, and provide a record in their tree rings, and sometimes fire scars, of past growing conditions and natural disturbances.
- Continue prescribed fire treatments to prevent further encroachment of forest onto native grasslands and woodlands. Maintain the Research Natural Areas and provide support and cooperation for habitat maintenance and restoration experiments and treatments.
- Manage forest areas to provide a full range of native forest structures, sizes, and stages of ecological succession at appropriate landscape scales. Given the predominance of young forest, this strategy for biodiversity is currently aligned with the strategy to develop a late-successional component for spotted owls. In the long-term, the question of what constitutes an appropriate proportion of younger forest environments within Fort Lewis must be addressed.
- Maintain multiple stands within each major ecological forest type in an unmanaged condition as “reference” stands for comparing the effects of management on stand structure (see Conservation Reserves, section III.B.4).

D. FISH AND WILDLIFE

1. MAINTAIN OR ENHANCE NATIVE FISH AND WILDLIFE POPULATIONS

The coarse filter strategies for developing or maintaining mature forest habitat, biodiversity, wetlands, and riparian areas will ensure habitat for most species at appropriate landscape scales. Additional strategies to ensure habitat for individual species are described in the Fort Lewis Fish and Wildlife Management Plan (U.S. Army 2000). Fort Lewis wildlife biologists should continue to study important species, particularly with respect to:

- Understanding detailed habitat needs for reproduction, foraging, and predator avoidance of species within forest and woodlands (e.g., for raptors, Reynolds 1983).
- Determining abundance of species and use of current structure in Fort Lewis habitats.
- Making recommendations for management to improve or maintain current structure.

Snags and coarse woody debris are key structural features of the forest with great importance to many species of wildlife. While general strategies call for accumulation of minimum levels across most forest areas, there is a priority for treatments to develop dead wood in areas of habitat critical for various species. These include:

- Existing mature forest currently deficient in dead wood.
- Areas in proximity to large openings.
- Areas in proximity to wetlands.

Until 1988,sound snags and logs were removed during harvest operations at Fort Lewis. Since that time, the policy has been to retain snags and logs during harvest. If snags pose a hazard to the loggers, they are felled but not removed. If logs are in the way of logging equipment, they are moved aside but not taken to landings. In more recent years, decadent trees (e.g., with cavities, conks, etc.) and potentially decadent trees (e.g., tops snapped off by the December 1996 ice storm) have also been retained. Twelve years of this policy has already produced noticeable accumulation of dead wood in some areas

This policy will be continued. Recent research has indicated that overstory trees that become decadent before dying provide maximum benefits for wildlife (Duncan 1999, Krajick 2001). This value continues for many years, through a period of decadence, a subsequent period as a snag, and a final period as a log. "Instant" snag creation by girdling or topping trees bypasses the important decadence stage. However, deliberate cavity creation in live trees can benefit cavity-nesting wildlife next to prairies, wetlands, etc.

Estimates of natural mortality rates in the Moist Forests indicate that trees greater than 20 inches DBH die at an average rate of one tree per acre every 6 years. On Dry Forest sites, trees greater than 16 inches die at a rate of one tree per acre every 10 years (Ahrens 1998b). This suggests a primarily passive strategy for accumulation of down wood, combined with strategic retention of cull and breakage during silvicultural treatments. Active treatments favoring decadence should emphasize creation of snags in many areas. A conservative approach to accumulation of down wood will also allow for evaluation of impacts on military training and development of methods to minimize interference between down wood and training activity.

E. RARE, THREATENED, OR ENDANGERED SPECIES

1. HELP MEET REGIONAL GOALS FOR RECOVERY OF THE NORTHERN SPOTTED OWL

The ecosystem management strategy promotes the development of forest structure suitable for spotted owls within the capabilities of the predominantly dry-site forest ecosystems. Specific management guidelines for achieving desired conditions for foraging, roosting, nesting, and dispersal are listed in the Habitat Management Plan for the Northern Spotted owl (Bottorff 1995). These are generally incorporated in or compatible with the strategies developed here for community types and Ecological Landscape Units.

Desired conditions for owl habitat call for suitable foraging habitat covering at least 60 percent of the forest (30,700 acres for Fort Lewis), including at least 40 percent (20,500 acres) suitable for nesting and roosting (Bottorff 1994). Although there are about 6,700 acres of stands older than 85 years, none of the stands sampled in the forest inventory simultaneously meet minimum criteria for large live trees, large snags, coarse woody debris, and multilayered canopies. Most of the sample stands meet none (57 percent) or only one (32 percent) of these criteria. Suitable habitat for dispersal of spotted owls can be achieved in the short-term; however, at least 40 to 50 years may be needed to meet the desired condition for foraging, nesting, and roosting habitat.

Desired conditions for spotted owls are currently based on typical conditions across the range of the owl (Bottorff 1994). The mosaic of Dry Forest, woodland, and prairie at Fort Lewis is very different from typical forest landscapes that support spotted owls. Further work is needed to develop both desired conditions and management treatments for spotted owl habitat that are more specifically applicable to Fort Lewis. The ongoing research of the Forest Ecosystem Study on Fort Lewis (Carey et al. 1999) will provide the basis for this.

A long-term, multi-stage approach is necessary to achieve the combination of desired structural characteristics. Treatments designed to improve important attributes in the long-term may reduce other desirable characteristics in the short-term. A variety of alternative, multi-stage prescriptions should be applied in order to learn more in the process of adaptive management.

2. MAINTAIN RARE, THREATENED, OR ENDANGERED SPECIES OF ANIMALS CURRENTLY OR HISTORICALLY RESIDENT AT FORT LEWIS

Of the 20 species of concern, six species (pileated woodpecker, northern spotted owl, marbled murrelet, northern goshawk, Vaux's swift, big-eared bat) benefit from the strategies to provide mature forest. Maintenance and enhancement of all waters and wetlands and associated forest will provide for an additional nine species (bald eagle, purple martin, common loon, spotted frog, Olympic mudminnow, northwestern pond turtle, northern red-legged frog, bull trout, and black tern). Objectives for maintaining and restoring woodlands also favor western gray squirrels; treatment of woodlands should make specific provision for western gray squirrels as further recommendations are developed.

Other specific strategies (fine filters) to protect species and habitat, with consideration at regional and local landscape scales, are discussed in the Fort Lewis Fish and Wildlife Management Plan and in several independent studies (U.S. Army 1998, Bottorff 1994, Carey et al. 1999, Ryan and Carey 1994, Bottorff and Swanson 1993). Fort Lewis staff should continue work to determine the occurrence of listed, candidate, and proposed species on the forest .

3. MAINTAIN RARE, THREATENED, AND ENDANGERED PLANTS

Strategies for protection of wetlands and riparian forests will ensure the protection of water howellia (*Howellia aquatilis*), which typically occurs under deciduous forest along the margins of seasonally flooded wetlands on Fort Lewis. No logging will occur within a 100-meter-wide buffer around the margins of wetlands known to contain this species.

Small flowered trillium (*Trillium parviflorum*) will be protected wherever it occurs in wetland fringes, riparian forest, and Moist Forests. Protection will be extended to any new sites identified by the LCTA program. Efforts will continue to determine the occurrence of listed, candidate, and proposed species on the Fort Lewis forest.

F. TIMBER

1. GROW AND HARVEST TREES FOR A VARIETY OF USES ON THE FORT

Military needs for timber (generally posts and poles of various sizes) are easily met by thinning and selective cutting of trees, compatible with the silvicultural strategies described in Section III.D and Appendix A. Harvest for military use is coordinated with the Forestry Program.

2. PRODUCE A SUSTAINABLE YIELD OF TIMBER

The predominant practices of thinning and selective cutting applied under the Ecosystem Management Strategies will provide a regulated harvest of 8 to 10 million board feet of sawtimber per year. This volume is about 40 percent of the net annual growth estimated for managed lands. This continuation of conservative harvest levels will provide for accumulation of late-successional structure, including large old trees, snags, and coarse woody debris. The long-term, sustainable harvest volume has not been determined and is dependent on future decisions concerning:

- The acreage of younger forest stages to be maintained across the Fort.
- Long-term allocation of volume growth to woody debris.
- Rotation ages for late-successional stands.

See recommendations for future estimation of growth and yield under Section II.G.4.

G. RECREATION AND SCENIC VALUES

1. MAINTAIN ATTRACTIVENESS OF IMPORTANT SCENIC AND RECREATION AREAS

Forest management activities will maintain scenic values and safe public access in designated scenic and recreational areas. These include the Fort Lewis Golf Course, camping areas at Chambers and Lewis Lakes, scenic corridors along the Nisqually River, and scenic buffers along some public highways.

H. CULTURAL AND HISTORIC RESOURCES

1. PRESERVE ARTIFACTS AND ATTRIBUTES OF CULTURAL OR HISTORIC IMPORTANCE

The occurrence of cultural and historic resource sites identified in forested areas (Figure 7) will be noted for pertinent stands in the Forestry Stands database. Design of management treatments should ensure protection of sites, as recommended by Larson and Lewarch (1994). Measures for protection of cultural resources will be addressed further in the Integrated Cultural Resources Management Plan, currently being prepared for Fort Lewis.

I. SOCIAL AND ECONOMIC VALUES

1. CONTRIBUTE TO EMPLOYMENT AND LOCAL COMMUNITY STABILITY

The Fort Lewis Forest will continue to contribute to local economies by providing a stable, sustainable harvest of sawtimber and firewood. Periodic revision of resource plans will provide estimates of the levels of timber that will be available for next period.

J. AIR QUALITY

1. COMPLY WITH DNR SMOKE MANAGEMENT PLANS AND CONTRIBUTE TO THE MAINTENANCE OF REGIONAL AIR QUALITY STANDARDS

The Forestry Program will minimize smoke from summer fires via continued efforts to prevent, detect, and suppress accidental forest fires. Prescribed burning will be done in accordance with Fort Lewis' Titale V air operating permit, and during appropriate seasons and climatic conditions in coordination with DNR smoke management and other Air Pollution Control agencies.

2. MAINTAIN HYDROLOGIC FUNCTION OF WATERSHEDS AND MAINTAIN WATER QUALITY ADEQUATE TO SUPPORT HEALTHY AQUATIC ECOSYSTEMS AND PROVIDE FOR WILDLIFE, DOMESTIC, MUNICIPAL, AGRICULTURAL, AND INDUSTRIAL USES

The strategies for buffering wetlands and riparian areas will generally prevent degradation of water quality due to forest practices. Continued maintenance of forest cover for other goals will also maintain watershed characteristics, hydrologic functions, and good water quality. Specific sites of water use will be protected during forest management activities.

L. WETLANDS AND RIPARIAN AREAS

1. PROTECT AND MAINTAIN WETLAND AND RIPARIAN ECOSYSTEMS AND THEIR FUNCTIONS, INCLUDING WATER QUALITY AND HABITAT FOR AQUATIC AND TERRESTRIAL LIFE

Wetlands and riparian areas will be protected through a conservative buffering strategy. Given the wide variety of riparian situations, protection of wetland or stream riparian areas is ensured with a

case-by-case process of site-specific evaluation and consultation for each proposed activity near the riparian zone. This is an interdisciplinary process undertaken by the Forestry Program and Fish and Wildlife staff.

Overstory and understory vegetation and soils will be protected in a riparian area that extends through the zone of transition between riparian and upland vegetation, soils, and canopy influence. No fixed buffer distance is applied.

Since most forest harvesting involves thinning or selection, the environment in managed forest stands *outside* the riparian zone is not greatly altered. As a consequence, any management activity *within* the riparian zone for forestry or wildlife purposes will not produce excessive exposure from proximity to cleared areas.

Major forested riparian zones associated with the Nisqually River and lower Muck Creek are protected with a variety of management classifications. About 1,800 acres of riparian zone are protected as Conservation Reserves, including Nisqually River Floodplain, Ellsworth Woods, and 13th Division Prairie RNA's. Forest management activities are also restricted from December 15 to August 15 within 500 meters on either side of the Nisqually River and lower Muck Creek for protection of wintering bald eagles.

V. IMPLEMENTATION

A. RESPONSIBILITY AND CAPABILITY FOR MANAGEMENT

The Forestry Program of the Fort Lewis Environmental and Natural Resources Division has overall responsibility for implementation of this forest management strategy. The predominantly gentle topography and well-developed road access greatly facilitate ecosystem management. The Fort Lewis infrastructure provides extraordinary capability to:

- Achieve integrated design and execution of stand-level treatments with site–specific, interdisciplinary cooperation.
- Maintain and update the information base for ecosystem assessment and monitoring.
- Execute effective prescribed fire treatments.
- Achieve immediate and effective wildfire control and suppression.

The approach recommended for prioritizing and selecting areas for treatment builds on the past procedure of identifying candidate stands, which is based on a 10-year cycle for treating individual stands (delineated on the Stands Base Map). This annual list of candidate stands will be the initial basis for considering treatments under the new strategies.

Selection of stands from the annual list of candidate stands should be based on evaluation of conditions in each stand, considered with respect to the priorities established for the community type, age-class, landscape subunit, and ecological landscape unit. The process of evaluation relies heavily on the experience and judgment of the Forestry Program foresters and biologists. For each candidate stand, they will evaluate the need for treatments, if any, based on application of the general priorities described under community types and ELU's, and based on the specific opportunities indicated by current stand attributes. In general, stands that have been entered within the last 10 years are not likely to need immediate treatment under the new priorities outlined here.

The Intensive Stand Inventory will, after completion of its first, 5-year cycle, provide a "snapshot" of a representative sample of stands in each of the three major, ecological forest types (Moist, Dry, and Colonization), as well as other Management Unit Categories occupying substantial total acreages. These data, in combination with timber-sale cruise information, stand inventories associated with specific projects (e.g., pine and oak woodland restoration), and improved GIS natural resources layers (e.g., as a result of the current wetlands inventory), will provide a more comprehensive database for choosing stands for treatment.

Stand-level planning for mature forest conditions must employ a long-term, multi-stage approach to achieving the combination of desired structural characteristics. Given the predominance of 45- to 85-year-old trees, it will take decades to develop substantial areas of mature forest structure. Treatments designed to improve important attributes in the long-term may often reduce other desirable characteristics in the short-term. A variety of alternative, multi-stage prescriptions should be applied in order to learn more in the process of adaptive management.

B. COORDINATION WITH OTHERS

To ensure that forest management activities do not harm training and, preferably, enhance it, the Forestry Program will maintain close coordination with military trainers. This will be accomplished by holding annual coordination meetings for the timber sale and prescribed burning programs, to which representatives of G3, Range Control, and other appropriate military units are invited. In addition, planning documents, such as the Oak Woodland Management Plan and the Forest Management Strategy, will be routed to appropriate military units for comment and concurrence.

The activities of the Forestry Program and the Integrated Training Area Management (ITAM) program in Range Control often overlap, primarily in the area of Scotch broom control, and sometimes ecological restoration of oak and pine woodlands. The potential exists for duplication of effort, or for management activities to be at cross-purposes. This can be minimized through the coordination meetings mentioned above, and through additional coordination mandated by the INRMP. The latter includes quarterly meetings between ITAM and ENRD, and joint development

of a GIS-based and web-accessible monitoring database and a web-based bulletin board for ongoing and planned ENRD and ITAM natural resources projects.

C. TIMEFRAME

This ecosystem management strategy provides an initial basis for management in the short-term (5-10years). The framework for this strategy is intended to be flexible enough to allow for changes in laws and knowledge over the short-term

D. AMENDMENTS AND REVISIONS

Army regulations require annual reviews of natural resources plans, such as this strategy, and complete revision every five years. This guarantees ample opportunities for adjustment and adaptive management.

VI. EXPECTED EFFORT AND OUTPUTS

A. ANNUAL CAPABILITY FOR TREATMENTS

The annual capability for silvicultural treatments will remain in the range of about 2,000 to 2,500 acres under current staffing. In addition, opportunities for supplemental resources from outside sources may arise for cooperative habitat restoration treatments. These may significantly expand the potential acreage of ecosystem management treatments in certain years. Recommendations are summarized below for approximate areas available over the next decade for active management under various major silvicultural objectives:

(1) About 23,500 acres of young forest management units are suitable for the primary objective of initiating structural diversity and accelerating forest succession.

(2) About 12,300 acres of stand units are suitable for the primary objective of enhancing existing mature forest attributes, including about 7,900 acres of young forest with residual old trees and 4,400 acres of predominantly older stands.

Within stand units included under the two major objectives above, there is also a priority to integrate the following objective:

- Maintain existing Oak Woodlands in stand units currently classed as conifer (about 2,800 acres) and retain or restore residual oak and pine components in Colonization Dry Forests (about 3,200 acres).

(3) About 7,900 acres are suitable for stocking control and initiation of desirable patterns in regenerating conifer stands.

(4) About 1,800 acres are suitable for facilitating long-term succession to conifers in early-successional hardwood stands.

(5) About 1,100 acres are recommended for intensive pine restoration in RNA's.

The acreages presented above should be used as an initial guide for allocating effort under the ecosystem management strategy. With the current capability for annual treatments, about half of the total available acreage suggested above can be treated over the next decade. This is appropriate for the conservative and adaptive approach to management at Fort Lewis. Supplemental resources from outside sources should be directed to experimental treatments and monitoring of ecosystem responses. Estimates of available acreages should be improved and updated, incorporating more detailed information on forest structure and opportunities for treatments, on a stand by stand basis.

B. FUTURE CONDITIONS

Fort Lewis ecosystems have been relatively unstable during post-settlement times, with directional change a predominant property of forest stands and landscapes. However, succession of sites from woodland to forest or from Dry Forest to Historical Moist Forest is also a natural characteristic of this landscape. **These dynamic conditions will continue for the next several decades**. Though a stable endpoint cannot be specified, the short-term management direction is clear, based on the immediate priorities for encouraging mature forest systems in a predominantly young forest landscape, and for restoring declining native communities.

With fire suppression, cutting of trees will continue to be the predominant cause of mortality. Fire-related processes will be reduced compared to native landscapes. These processes include consumption or alteration of the litter layer, concentrated volumes of fire-killed timber returning to the system, consumption of fine fuels, effects on understory plants, effects on soil chemistry, inputs of ash, volatilization of various organic compounds, etc.

While recent measures of forest growth indicate that Fort Lewis' forests are quite productive, historically fire maintained most of these forests at relatively low levels of standing biomass. The twin goals of restoring some forests towards their pre-European condition and reducing the risk of catastrophic wildfires thus conflict with the goal of increasing dead wood to create high-quality, spotted owl habitat.

Prescribed fire and accidental ignitions will maintain some fire-related processes, particularly at ecotones with woodlands and prairies where frequent use of fire is quite practicable. However, the use of prescribed fire in the interior forest will probably continue to be limited by priorities for fire prevention. Thus, forest ecosystems will continue to develop in a fire suppressed disturbance regime. Continued site succession will probably occur within forest communities, with some sites moving towards moister vegetation types.

At some point in the future, a more stable set of conditions may be achieved, with the forest dominated by mature conditions and with renewal of successional cycles taking place on a small but constant portion of the landscape in patches within stands or occasionally in stand replacement disturbances.

Based on current age structure and rates of tree growth and tree mortality, a rough estimate of the Fort Lewis Forest's capability to develop mature forest cover is about 30,000 acres over the next 50 years. Better estimates of both short- and long-term rates of structural development will depend on the completion of the current Intensive Stand Inventory (first results in year 2003) and development of stand-projection systems based on characterization of both treatments and responses at Fort Lewis.

About one-third of the maturing forest will be composed of Moist Douglas-fir/cedar/hemlock forest, primarily even-aged Douglas-fir in the overstory with mixed age components of intermediate cedar and some hemlock developing. This Historical Moist Forest will develop in an increasingly stable and uneven-aged matrix of the predominant Dry Forest. The forest landscape should continue to be resistant to large-scale catastrophic fire with the maintenance of discontinuous fuels in both the Dry/Moist matrix of contiguous forest and the larger landscape pattern of interweaving prairies and woodland.

Existing pine and oak habitats will be stabilized and expanded. Significant pine and oak components will be maintained within colonizing forests currently dominated by Douglas-fir.

Wetland forests and riparian areas will remain intact.

C. EXPECTED OUTPUT OF NATURAL RESOURCES AND USES

Timber harvest volumes resulting from silvicultural treatments will remain in the range of 8 to 10 million board feet per year during the next decade. This is about one third of the current net volume increment, since growth of timber will continue to accumulate in the maturing forest.

Poles will be harvested as needed for military activities. Cutting of small trees for this purpose will be coordinated with silvicultural prescriptions for precommercial thinning whenever possible.

Firewood harvests will be reduced from the levels of previous decades to provide more input of coarse woody debris, though removal of down wood near roads will continue.

Intensive use of forested training areas will continue, with about 25,000 military personnel to be stationed at Fort Lewis during the next five years.

Traditional uses of the forest by Native Americans from the adjacent Nisqually Reservation will continue.

Recreational uses by members of adjacent communities will continue to be allowed in certain forested areas (includes hunting, fishing, hiking, birdwatching, horseback riding).

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