FOREST MANAGEMENT PLAN

U.S. ARMY
JOINT BASE LEWIS-McCHORD
WASHINGTON

prepared by

Forestry Branch, Environmental Division
Directorate of Public Works

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EXECUTIVE SUMMARY

This plan describes management of 62,700 acres of forest, woodland, and savanna on Joint Base Lewis McChord (JBLM), a joint Army-Air Force installation near Tacoma, Washington. The forest landscape is mostly second-growth conifer stands following logging or where conifer forest now occupies former woodland and grassland. Hardwood-dominated and mixed (conifer/ hardwood) stands are also common. The dominant tree is Douglas-fir (93% of basal area, 97% of commercial wood volume). Other major species are western redcedar, red alder, bigleaf maple, and western hemlock. Oregon white oak occurs across 3,900 acres and ponderosa pine across 5,100 acres, mostly in woodlands or savannas, where they are often the dominant species. Black cottonwood and Oregon ash are found in wetlands.

JBLM's forests are underlain by glacially-derived soils that originally developed under either forest or grassland vegetation. These soils are generally very well- to extremely well-drained, with high rock content, and resistant to erosion and compaction. Steep slopes are uncommon. A dense network of mostly dirt roads exists as a result of decades of military training.

The Forestry Branch, Environmental Division, Public Works, manages JBLM's forests for military training, production of forest products, biodiversity, and fire risk reduction. We use an ecosystem management approach that emphasizes the biological, military, social, and economic values of the forest. Toward this end, we have been certified since 2002 as a sustainable forestry operation by the Forest Stewardship Council, an independent organization.

The total timber inventory is about 2 billion board feet. Past forest management has been primarily light thinnings (10-20% of trees removed) and, in some cases, clearcuts. Current timber harvest is predominantly variable-density thinning, where the objective is for the post-harvest stand to be more heterogeneous, horizontally and vertically, than the pre-harvest stand. During the past five years, there has been an annual average of 13 timber sales across 1,382 acres, producing 9.0 million board feet of commercial wood that is harvested mostly by small logging companies. Most commercial wood is sawtimber, with some roundwood, pulpwood, and firewood.

Forty percent of net timber sale revenues is sent to Pierce and Thurston counties to support roads and schools. The overall economic impact of JBLM's forestry program on the surrounding region is small, but a number of small forestry contractors rely in part on contracts to log, control brush, etc., on JBLM.

A stand development program prepares harvested sites for tree planting, using both mechanical and chemical methods to eliminate competing brush. It focuses on reduction of Scotch broom, a rapid-growing, non-native shrub that significantly reduces planted tree growth, and, in some areas, on reduction of dense native brush. Other non-native forest understory species (e.g., English ivy) are also being controlled.

Forest management includes ecological restoration of uncommon, degraded forest ecosystems, especially stands dominated by oak and pine. Restoration tools include tree and brush removal, prescribed fire, and planting of desirable tree species. A network of conservation reserves has been designated, including reference stands where there has been no management since the 1940s. These reserves include one stand of old-growth conifer forest. In certain areas, we also manage for the state-listed western gray squirrel and for the habitat of the federally-listed northern spotted owl.

JBLM Forestry is the primary responder to wildfires on JBLM, which are caused mostly by live-fire exercises (i.e., exploding munitions and tracers). The fire manager position in Forestry also has primary responsibility for prescribed fires, although these are carried out primarily by JBLM Fish & Wildlife personnel. In forested areas, prescribed fires are conducted mainly for ecological restoration and to reduce fuels.

JBLM Forestry conducts extensive monitoring of forest resources. Our forests are divided into 1,364 stands of ten acres or more in size, which are systematically inventoried over time using stand exams. In addition, there is specialized monitoring of conservation reserves. We use remote sensing in our monitoring, especially light detection and ranging (LiDAR) technology.

This plan will remain in effect until there is (1) a major change in on-the-ground conditions, (2) a major change in law or policy affecting Army forest management, or (3) a major revision of the JBLM Integrated Natural Resources Management Plan, of which this Forest Plan is a part.

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PURPOSE

Joint Base Lewis-McChord (JBLM) is a 91,126-acre US Army installation located between Tacoma and Olympia, Washington State (Figure 1). JBLM has approximately 61,000 acres of *forest*, *woodland*, and *savanna*, most of which are actively managed for military training and for commercial and non-commercial natural resource uses. There are also 20,000 acres of grassland (colloquially known as "prairies") and 3,850 acres of wetlands (including 1,200 acres of forested wetland). The majority of the surrounding landscape consists of cities, towns, and suburbs; industrial development; and rural agriculture and forestry. Thus, JBLM is like an island of natural land in a sea of development.

Since 1953, the US Army has maintained a formal forestry program at JBLM, currently known as the Forestry Branch. Over the years, management practices on JBLM have changed with the times, reflecting the evolution of professional forestry and shifts in the goods and values the public desires from forests. Military training has always been the primary mission of JBLM, both constraining and enabling innovation in forest management. Yet, each Army installation is free to run its forestry operation as it sees fit, without annual timber harvest goals set by higher authority. Thus, this Forest Management Plan largely reflects the vision and professional judgment of the Forestry Branch.

JBLM FORESTRY MISSION

The mission of the Forestry Branch is to provide good stewardship of the forested training lands of Joint Base Lewis-McChord by ensuring the continued existence of a healthy forest that supports military training, sustains native plants and animals, and benefits local communities.

FORESTRY MANAGEMENT PHILOSOPHY

Although military training is the primary mission of JBLM, the Army, like all federal agencies, is subject to federal environmental laws. Because the land base is fixed and can't be expanded, the competing demands of training and environmental protection on JBLM are intensifying as the nation engages in overseas military operations and as our natural ecosystems become increasingly rare regionally. Managing these competing demands requires a management approach that considers the long-term health and sustainability of the installation's ecosystems. *Ecosystem management* is the guiding principle for JBLM's natural resources, including forests. It is an approach which aims to sustain *ecosystems* indefinitely into the future to meet both ecological and human needs. As such, it is an extension of the concept of *sustainability*, which extends the ecosystem management approach to all human activities. Major goals and management direction are derived from the integration of societal desires and ecosystem capabilities. Societal desires include the primary mission of JBLM - military training – and the production of both tangible and intangible forest products, including commercial timber harvest, firewood, recreation, and rare and threatened ecosystems and species.

The JBLM Forestry Branch has developed *Desired Future Conditions* (DFCs) for our various ecosystem types and components that help us set goals, objectives, and management actions (see Chapter Three). An example of a DFC is for ponderosa pine (*Pinus ponderosa*)-dominated stands: eventually, we would like these to possess pines of all sizes and ages, distributed patchily

across stands, with few shrubs, little coarse woody debris, and understories dominated by native grasses and forbs.

Active management (direct human intervention) is needed to meet the goals of ecosystem management for JBLM. Many factors that affected native ecosystems are absent in the modern environment (e.g., fire) or did not exist prior to European settlement (e.g., invasive, non-native plants). The result has been a substantial alteration – usually habitat degradation – of JBLM's ecosystems compared to pre-European times. Active management can, in many cases, emulate missing factors and reduce the influence of new factors. For some ecosystems and the plant and animal species that depend on them, active management must continue indefinitely at some level; these ecosystems and species are considered *conservation reliant*.

NEED FOR A REVISED PLAN

JBLM's forests have been managed under a Forest Management Strategy (Public Forestry Foundation 1995) since 1996. The Strategy received minor revision in 2001 and 2005. In late 2011, the JBLM Forestry Branch determined that a major revision of our management plan was warranted, for the following reasons:

(1) There have recently been significant changes in on-the-ground conditions in our forests:

- The average age and size of JBLM's trees have increased substantially since the last management plan in 1996.
- There has been a large increase in the geographic extent and severity of a major tree disease, laminated root rot (*Phellinus sulpharescens*).
- Non-native Scotch broom (*Cytisus scoparius*) has continued to invade forested areas and stifle conifer growth in forest *plantations*.
- Prescribed fire has become a major management tool for ecological restoration of woodlands and savannas.

(2) There have recently been significant changes in our forest management focus and legal requirements:

- Between 1994 and 2008, most of the Fort Lewis portion of JBLM was designated critical habitat for the northern spotted owl (*Strix occidentalis caurina*), a threatened species under the federal Endangered Species Act (ESA). In January 2012, the Army was notified by the U.S. Fish and Wildlife Service (USFWS) that critical habitat designation would return to JBLM late in 2012, but an exemption would be granted if we had an Endangered Species Management Plan (ESMP) which provides a net conservation benefit to the species. The exemption was granted by the USFWS on November 2012. Thus, the emphasis of the current Forest Management Strategy on the accelerated development of spotted owl habitat must continue in the revised plan, but with reduced geographic scope.
- JBLM's population of western gray squirrel *(Scirius griseus*), a state-listed threatened species, is increasing in response to habitat restoration and augmentation by individuals *translocated* from other Washington State populations. The habitat needs of this species are influencing an increasing proportion of JBLM's timber sale program.

- The recent listing of several, grassland-dependent species (Taylor's checkerspot [*Euphydryas editha taylori*), streaked horned lark [*Eremophila alpestris strigata*], two subspecies of Mazama pocket gopher [*Thomomys mazama*]) that occur on JBLM may affect how forest-grassland margins are managed.
- For 15 years, JBLM's forestry program has been certified as a sustainable forest by the Forest Stewardship Council (FSC). Recent changes in FSC forest management guidelines require substantial actions by, and impose new constraints on, Forestry to retain certification.

(3) We have acquired considerable new knowledge about the ecology and management of JBLM's forests:

- Research funded by the Forestry Branch has given fresh insights into such issues as securing successful conifer regeneration; controlling competition from Scots' broom; releasing minor tree species from *suppression* by Douglas-fir (the dominant species at JBLM); and the extent, effects, and control of laminated root rot.
- Application of new measurement techniques, including remote sensing, has increased the accuracy and spatial resolution of *GIS* layers for vegetation, soils, etc., and has given us the ability to do high-accuracy, repeat monitoring of forest resources

The plan contained in this document represents this major revision.

HOW THIS PLAN IS ORGANIZED

The Background chapter describes the environmental and forest management history of JBLM, an overview of the current status of JBLM's natural resources, and a detailed look at the current status of JBLM's forest resources and forest management program.

The Goals, Objectives, and Management Actions chapter describes the goals, objectives, and management actions that guide forest management on JBLM.

The Ecosystem Management Guidance chapter lays out general strategies for JBLM's various forest types. Each strategy consists of a vision for the future (DFC) and guidelines to help attain that vision.

The Implementation chapter describes resources available for implementation, the process by which forest management projects are approved, specific implementation requirements, the forest monitoring program, and plan review and revision.

The Fort Lewis Oak Woodland Management Plan (GBS Forestry 2002), once a separate plan from the Forest Management Plan, is now incorporated into this new Forest Management Plan.

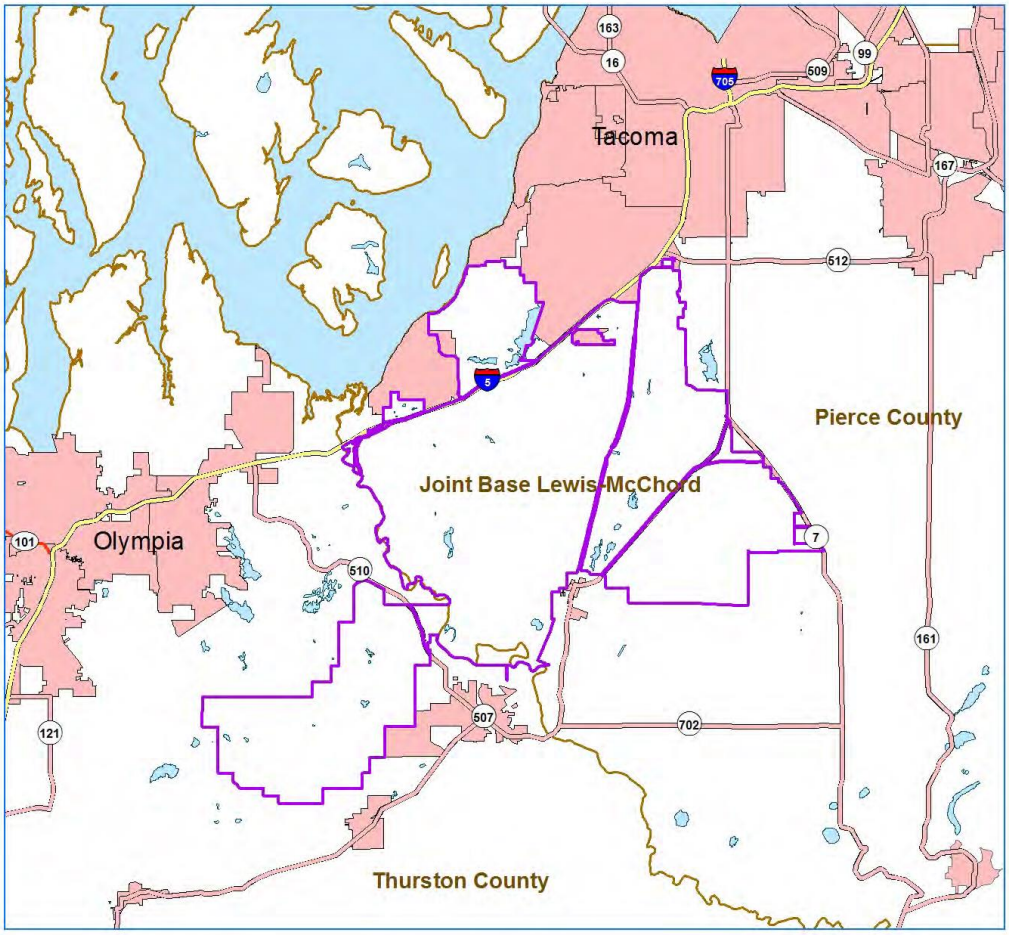
Latin names for species are italicized, as per convention. In addition, the first time a technical term is used, it is italicized. The Glossary provides definitions of these technical terms.

BACKGROUND

LOCATION

Joint Base Lewis-McChord (JBLM) is located in western Washington State, in the Puget Lowland between Tacoma and Olympia (Figure 1).

Figure 1. Vicinity map for Joint Base Lewis-McChord.



LEGAL REQUIREMENTS

Army Regulation 200-1 (AR 200-1; US Army 2007) requires all Army installations where "conservation reimbursable forestry or agricultural outleasing activities consist of 100 acres or more" to "practice responsible stewardship of forested lands to support the mission." There is no legal requirement for Army installations to have forestry programs or commercial timber sales. However, such programs are authorized under AR 200-1 and are considered "reimbursable," which means that the costs of these programs are borrowed from appropriations to the Department of Defense (DoD) by Congress and reimbursed by receipts from commercial sales of forest products. In practice, Army forestry programs typically pay part or all of such installation services as wildland fire suppression, dirt road maintenance, and manipulation of forest stand structure to support military training.

Army forestry programs act relatively independently, with no timber harvest targets or uniform management requirements. However, under the Sikes Act (16 USC §§ 670a-670o), each installation with significant natural resources must have an Integrated Natural Resources Management Plan (INRMP). INRMPs must be signed off by the USFWS and the appropriate state wildlife agency (in JBLM's case, the Washington Department of Fish and Wildlife [WDFW]). INRMP revisions occur on no particular timetable, but only if "circumstances have changed" (AR 200-1). The INRMP was created in 1999 and revised in 2007, covering only Fort Lewis (prior to joint basing in 2010). The draft of a new revision of the INRMP (including McChord) currently awaits USFWS and WDFW signature, expected before the end of 2017.

JBLM has separate, detailed plans for specific resources, such as forestry or fish and wildlife, which are incorporated into the INRMP by reference.

SUSTAINABLE FORESTY CERTIFICATION

In 2002, Fort Lewis became the first Federal ownership in the US to be certified as a sustainable forestry operation by the non-profit Forest Stewardship Council (FSC). Each certification lasts five years. Fort Lewis was recertified in 2007 and again (as JBLM) in 2012. To be certified, forest ownerships must meet all of the applicable Principles and Criteria of FSC (Forest Stewardship Council 2002). In addition, US ownerships must meet the specific requirements of the FSC-US Forest Standard (Forest Stewardship Council 2010). These principles, criteria, and standards cover a broad spectrum that includes biological, economic, and social considerations.

To remain certified, JBLM Forestry receives annual, on-the-ground audits and, every five years, a recertification audit. The outcomes of these audits consist of two types: (a) Corrective Action Requests (CARs) are things we are required to do, by specified deadlines, to retain certification. (b) Observations are additional suggestions to improve our forest management, but are not required to maintain certification. However, if they are not complied with, they have the potential to become CARs.[1]

Currently, the certified area (55,509 acres) of JBLM covers most of the forested portion of the training areas (Figure 2).[2]

FOREST HISTORY

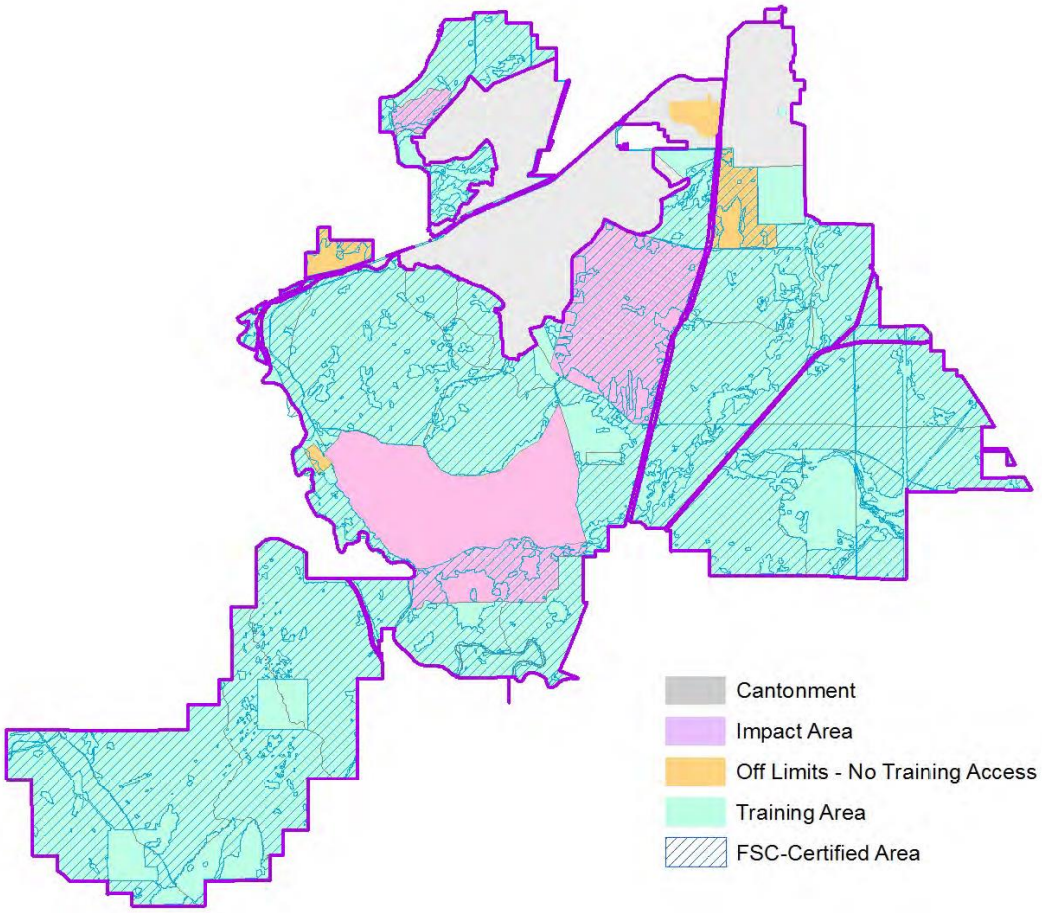
PRE-SETTLEMENT

The environmental history of southern Puget Sound, prior to Euro-American settlement in the mid-1800's, is important to understand because it explains much of the variety of forest types found today on JBLM.

[1] CARS are also part of JBLM's environmental management system, a requirement of Executive Order 1369 (The White House 2015).

[2] Forestry Branch operations also support the Army Strategy for the Environment (US Army 2004) and the training lands goals of the JBLM Installation Sustainability Program (US Army 2017).

Figure 2. Land-use designations and the Forest Stewardship Council-certified area at Joint Base Lewis-McChord.



Pleistocene

During the last Ice Age, a continental glacier occupied the Puget Lowland, extending all the way to southern Thurston County. At its furthest extent, the glacier created a *terminal moraine* just south of Tenino and Rochester. The glacier began melting away about 12,000 years before present (BP). This was not a uniform process. For example, after an initial phase of melting back, the glacier stayed in place for a while, creating a *recessional moraine* across the Rainier Training Area (RTA; Kruckeberg 1991).

During ice retreat, catastrophic floods reworked much of the JBLM landscape. The sources of these floods were deep lakes formed between the edge of the continental icesheet and the foothills of the Cascade Mountains. As the ice melted away, the "ice dams" that backed up the water thinned and broke, releasing the lakes' water in sudden floods. One flood originated from the upper Carbon River Valley and flowed across the southern RTA (Goldstein et al. 2010). Additional floods originated in glacial Lake Puyallup, northeast of JBLM, and flowed across western Pierce County (Troost 2007). In both locations, large *fluvial terraces* were created and finer sediments were removed, leaving behind very rocky *outwash* deposits such as Steilacoom Gravel. Subsequently, *mima mounds* developed on several thousand acres of flood terraces in the southern Puget Lowland.

Holocene

Following de-glaciation, the Puget Lowlands were buried in up to 1,000 feet of glacial deposits, with very little bedrock exposure. There was no organic matter and no propagules of plants and animals. The landscape then underwent *primary succession*, during which soils and vegetation became established. There was no real endpoint to this succession, because the regional climate underwent significant changes during the 14,000 years between the start of deglaciation and the present day, a period known as the Holocene.

The history of revegetation of the Puget Lowland has been reconstructed by scientists examining pollen and plant fragments preserved in lake sediments and peat bogs, including Nisqually Lake on JBLM (Whitlock and Knox 2002, Hibbert 1979). The climate during and immediately after deglaciation (≈ 14,000-12,000 years BP) was cold and dry, and tundra-like vegetation developed on the glacial deposits. Later, as the climate ameliorated and soil accumulated, shrubs and lodgepole pine (*Pinus contorta*) became prominent, later (≈ 12,000 years BP) joined by Engelmann spruce (*Picea engelmanii*) and red alder (*Alnus rubra*) to form a subalpine-like parkland. Between ≈ 10,000 and 6,000 years BP, the climate was warmer and drier than today. During this period, known as the Hypsithermal, a mosaic of Douglas-fir (*Pseudotsuga menziesii*) forests, grasslands, and Oregon white oak (*Quercus garryana*) woodlands became established. After the Hypsithermal, the climate became cooler and wetter, and western redcedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), and Oregon ash (*Fraxinus oregana*) became abundant, followed by western hemlock (*Tsuga heterophylla*) after approximately 4,400 years BP.

However, nearly half of the southern Puget Lowland, and the majority of JBLM, remained in a grassland or woodland condition because of periodic fires set by Native Americans to encourage game and native grassland food plants such as camas (*Camasia quamash*) and bracken fern (*Pteridium aquilinum*) (Perdue 1977, Norton 1979). These fires killed most shrubs and conifer seedlings that tried to establish in grasslands and woodlands. In drought years, grassland fires

spread into adjacent conifer forests, *underburning* the shrubs and ground fuels, but occasionally becoming *stand-replacement crown fires*.

POST-SETTLEMENT

The first permanent settlement in the southern Puget Lowland was Fort Nisqually, established in present-day Dupont, WA, by the Hudson's Bay Company in 1832. The company later created the Puget Sound Agricultural Company to grow crops and raise livestock to feed the various Hudson's Bay outposts in the Pacific Northwest. The first map of the Fort Lewis area (Huggins 1852) shows extensive grasslands and an area of "red pine" (ponderosa pine) in the vicinity of the modern Central Impact Area.

Land surveys by the Government Land Office in the mid-19th century reveal a JBLM landscape consisting of large grasslands, fringed with woodlands and interspersed with islands of conifer forest. The grasslands occurred on glacial outwash, the forests on *till* and moraine. On average, the forests had lower stem densities and greater average stem diameter than modern forests (Public Forestry Foundation 1995: Appendix C) (Table 1), representing the influence of fire. The dominant species was Douglas-fir. Moist forests with hemlock and cedar occurred primarily in the Rainier Training Area, where fire frequency was probably lower. Oak was more abundant than today, and ponderosa pine was present. About the same proportion of the landscape was occupied by trees, but there was more woodland and savanna in 1853 than in 1993 (Public Forestry Foundation 1995: Appendix C) (Table 2).

Table 1. Relative abundance and size of tree species on Fort Lewis, 1853 and 2004.

	Percent of Basal Area		Mean Diameter (in)	
Species	1853	2004	1853	2004
Douglas-fir	60.7	86.5	22.3	17.6
Oregon white oak	21.5	0.7	21.5	10.2
Western redcedar	9.8	3.2	23.2	17.8
Ponderosa pine	3.7	0.7	31.0	15.9
Western hemlock	2.3	1.1	23.0	15.3
Red alder	0.6	2.7	9.3	14.0
Bigleaf maple	0.3	2.3	9.6	13.4
Oregon ash	0.3	0.7	13.9	11.6
Sitka spruce	0.8	0.2	40.0	18.0
Black cottonwood	n/a	1.3	n/a	17.3

Table 2. Distribution of major vegetation types on Fort Lewis, 1853 and 2004.

	Percent of Total Area	
Vegetation Type	1853	2004
Moist conifer forest[1]	15	15
Dry conifer forest[2]	30	40
Pine/Douglas-fir forest	unknown	2
Oak/Douglas-fir woodland	6	5
Oak/pine savanna	7	1
Grassland	36	24
Urban	0	9
Water	4	3
Other	0.3	1

[1]Includes forested wetland. Assumed no change between 1853 and 2004.

[2]Includes both historical dry forest and prairie colonization forest.The displacement and high mortality of Native Americans that occurred with Euro-American settlement resulted in greatly reduced fire frequency, so that as early as the 1850's, settler diaries record encroachment of conifers onto former grassland (Kruckeberg 1991). Throughout the rest of the 19th century, development associated with settlement resulted in substantial direct loss of grasslands, woodlands, and forests, and conifer encroachment continued. The grasslands were subjected to plowing and grazing. As a result, much of the original grassland, dominated by a bunchgrass, Roemer's fescue (*Festuca roemeri*), was replaced by imported European pasture grasses (Norton 1979). Conifer encroachment into grasslands and woodlands accelerated when effective fire suppression began at the start of the 20th century, and continues to the present (Foster and Shaff 2003).

Logging in the JBLM region began about 1890 along the Nisqually River. By 1910, nearly all of the Pierce County portion of JBLM had been logged. The Thurston County portion was logged mostly during the 1920s and 1930s, and some in the 1940s. Much of the logged land accidentally burned over.

ARMY OWNERSHIP

The citizens of Pierce County donated 67,000 acres to the Army in 1917 to train soldiers for World War I. At the same time, the Army condemned 70% of the Nisqually Tribe's original reservation, i.e., all Indian lands northeast of the Nisqually River. During World War II, 17,160 acres of cut-over private timberlands were acquired by the Army in Thurston County and added to Fort Lewis as the Rainier Training Area.

Organized forest firefighting commenced in 1933 with the establishment of Civilian Conservation Corps camps on Fort Lewis. Subsequently, firefighting was carried out by the military. Not until 1968 was a civilian firefighting program started (US Army 1976).

The Army employed both *clearcutting* and *selection harvest* on JBLM. Clearcutting occurred in the Argonne Forest (Training Area 4) in 1934-35. Between 1947 and 1952, the U.S. Army Corps of Engineers (USACE) harvested 121 million *board feet* (MMBF) from Fort Lewis with a series of logging contracts overseen by a professional forester. Milling of the cut trees was done on site. Harvest came from clearcuts in Davis Woods, Mitchell Woods, Clayton Woods, and Hardy Hill, and from *individual-tree* and *group selection* harvests elsewhere. Subsequently, "harvesting was reduced in an effort to help the forest recover from the severe overcut by these contracts" (US Army 1976).

Throughout early Army ownership, conifer encroachment onto grasslands in the absence of fire continued, as documented by aerial photographs from 1942 and subsequent years (Foster and Shaff 2003), and by direct observation (Hansen and Carbaugh 1966). This happened despite regular wildfires, mostly on grasslands; between 1944 and 1975, an annual average of 342 acres of Fort Lewis burned in wildfires, 70% of these acres in "grass" (US Army 1976).

Army Forestry

A formal forestry program was established at Fort Lewis in 1953. The first forest management plan was developed in 1947. A new plan was prepared in 1961, with revisions in 1961, 1966 (Hansen and Carbaugh 1966), 1971, and 1976 (US Army 1976).

Between 1954 and 1964, timber harvest consisted of *salvage* logging, *timber stand improvement* cuts, and clearing for new construction, averaging 3.4 MMBF per year, with one exception: The Columbus Day storm struck the coastal Pacific Northwest in 1962, followed by the largest salvage sale in JBLM history, 15.5 MMBF or 3% of the 1963-64 forest *inventory*. By 1964, the age and canopy structure of nearly every forested acre on Fort Lewis was the result of one or more harvest entries or post-settlement wildfires, and 90 percent of the forest was less than 70 years old. Standing commercial wood inventory was only 430 million board feet, less than one quarter of the current inventory.

Between 1966 and 1971, average annual harvest increased to about 20 MMBF, then declined to 16 MMBF between 1972 and 1976, and to 9 million MMBF from 1977 to 1981. Most of the harvest during this period was for *pulpwood* and firewood due to the small size of the trees growing back following earlier clearcutting and burning. Since 1981, with larger trees, logging has removed primarily *sawtimber*, with an annual average treated area of 2,000-3,000 acres. Most of this harvest has been in the form of *thinning* rather than clearcutting.

Starting in the early 1990s, the primary harvesting regime at Fort Lewis shifted from traditional thinning, which creates more uniform forests over time, to *variable-density thinning* (VDT), which creates more structurally diverse forests over time. The forest management plan was completely rewritten in 1995, adopting an ecosystem management approach (Public Forestry Foundation 1995), and revised in 2001 and 2005.

CURRENT CONDITIONS

LAND USE

Cantonment

The cantonment is the developed portion of the installation (Figure 2). It serves as the center for most activities on JBLM, apart from military field training. Land uses in the cantonment include

family and troop housing; administrative, commercial, and industrial uses; and open space maintained as green belts and recreation areas. McChord Airfield supports fixed-wing aircraft, including C-17 cargo jets, while Gray Army Airfield supports both fixed-wing aircraft and helicopters.

Training Areas

JBLM's training lands are divided into 31 training areas, four impact areas, and the Ammunition Storage Point. Training area activities include on/off-road vehicle maneuver, placement of temporary targets, digging (vehicle positions, *tactical operation centers*, foxholes), helicopter landing/takeoff, unit assembly, and unit deployment exercises. Also occurring on the training areas are non-military uses, e.g., forestry, fish and wildlife management, recreation, and traditional tribal uses. Impact areas support live-fire gunnery, including small arms, mortars, machine guns, and artillery.

Controlled Use Areas

Portions of JBLM have been designated as Controlled Use Areas (CUAs) where land-use activities are restricted, seasonally or year-round (Figure 3). CUAs contain unique attributes that require preservation, conservation, or restoration, or pose a safety hazard. Land-use restrictions are mostly associated with regulatory compliance (e.g., bald eagle nest buffers, cultural sites, wetlands) or have been put in place voluntarily to prevent additional future restrictions on training (e.g., areas of high-quality grassland that provide habitat for species listed under the federal Endangered Species Act [ESA]).

CLIMATE

Western Washington has a temperate maritime climate characterized by long wet winters and short dry summers. Mean annual temperature is 51^{o}F. The coldest month is January and the warmest months are July and August. There is a geographic gradient of annual precipitation across the area, from 50 inches in Olympia to 40 inches at Gray Army Airfield to 36 inches in Seattle. Measurable precipitation occurs, on average, 157 days per year. October through May is typically the wet season, with ten or more days of precipitation per month. Mean annual snowfall in the Puget Lowlands is only eight inches. July through September is typically the dry season, with less than ten days of precipitation per month. In any given year, the length of the summer drought varies from one month to more than three months, but the average is about eight weeks. Prevailing winds are from the southwest year-round.

TOPOGRAPHY

Elevations at JBLM range from sea level to 650 feet. Most of the terrain is flat or gently rolling (Figure 4). Large hilly areas occur in Training Areas 4, 5, 19, 20, 21, 22, and 23, with an average vertical relief of 100-300 feet. Steep slopes are uncommon, occurring mostly along the bluffs above Puget Sound and the Nisqually River.

Figure 3. Controlled use areas at Joint Base Lewis-McChord.

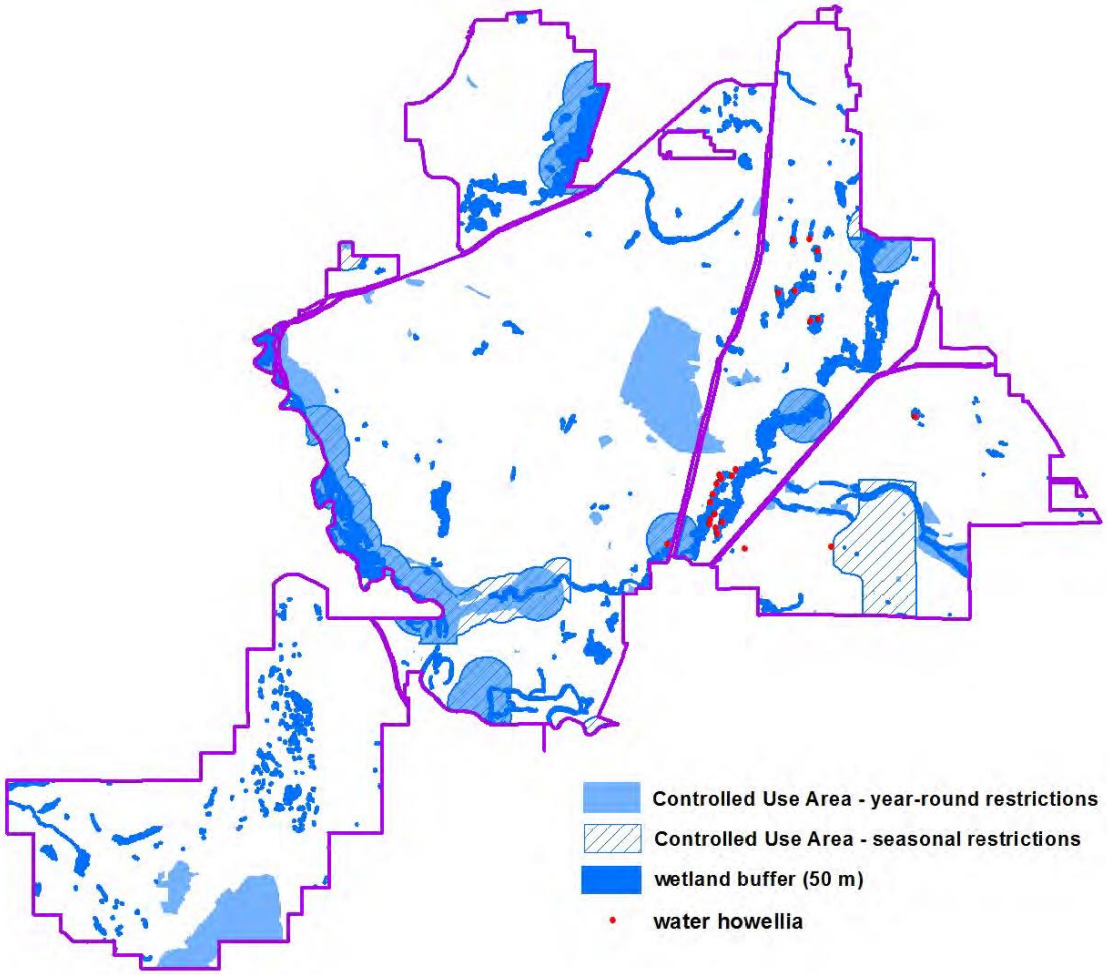
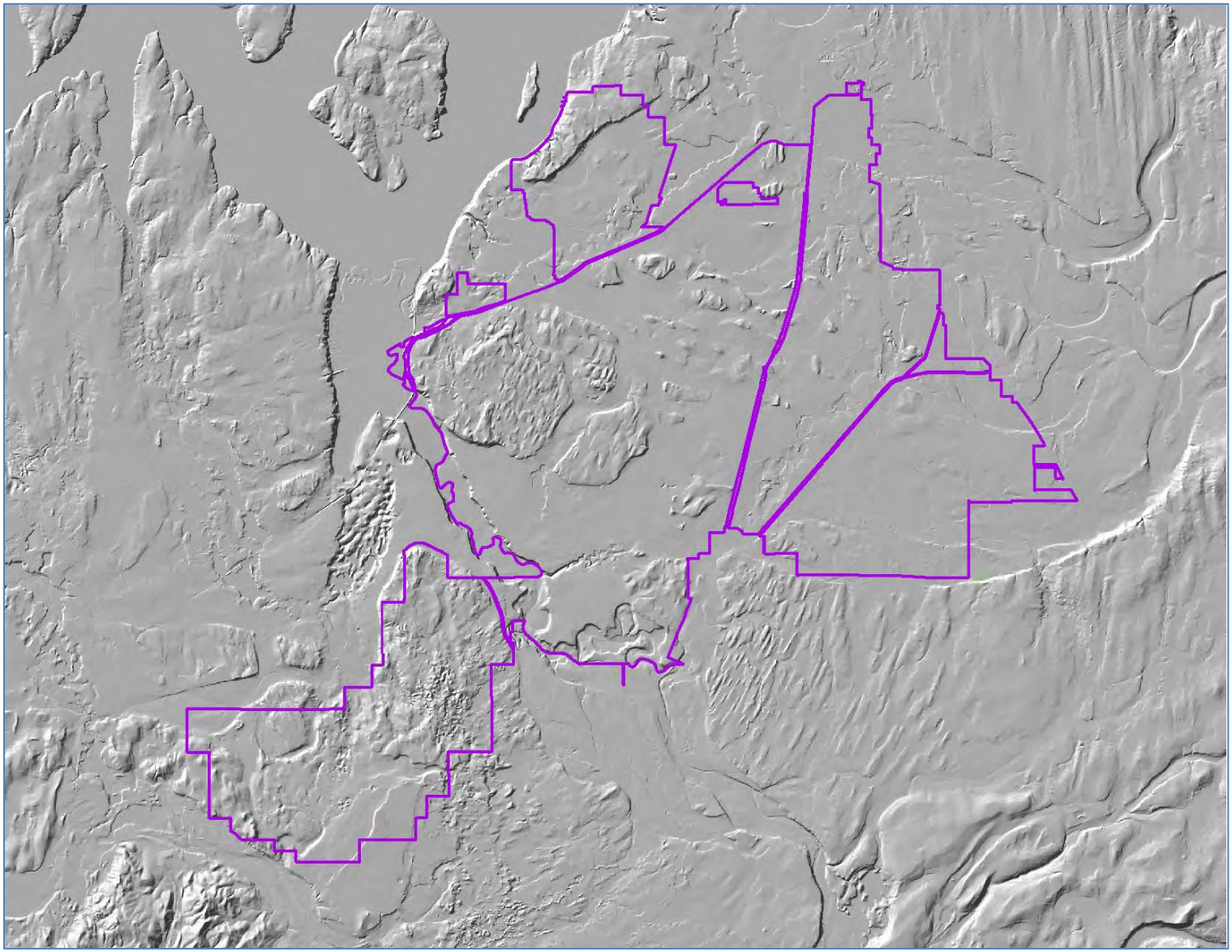


Figure 4. Shaded relief map of Joint Base Lewis-McChord.



GEOMORPHOLOGY

JBLM landforms are primarily glacial; there is virtually no bedrock exposure. Forty-two percent of JBLM is occupied by glacial outwash, which forms flat to undulating terrain. Similarly abundant are glacial till and moraine (43% of JBLM), which occur as hills rising above the outwash. Most of these hills are *drumlins*, elongated ridges aligned with the direction of the continental ice flow. The mid- and northern RTA is occupied by a recessional moraine, creating a very rough topography of numerous small hills separated by hollows lacking external drainage. Additional glacial landforms are an *esker* in Training Area 4 and numerous *glacial potholes* on the outwash, many currently filled by lakes or wetlands.

At JBLM, mima mounds are found in the Rainier Training Area grasslands, the Artillery Impact Area, and 13th Division Prairie, including adjacent conifer forests that have colonized former grassland (Walsh and Logan 2005, Logan and Walsh 2009). The cause of the mounds is still debated (e.g., Washburn 1988).

SOILS

Soils at JBLM are classified according to how *well-drained* they are, their organic matter content, and the type of vegetation they formed beneath. Within these coarse criteria, the soils are further classified into series. The Natural Resources Conservation Service (NRCS) recently completed a new soil survey of JBLM (NRCS 2014; Figure 5).

Fifty-eight percent of JBLM is underlain by soils that formed under grassland vegetation. These occur on glacial outwash and are excessively well-drained. The most widespread grassland soil series at JBLM is the Spanaway (55% of JBLM, including complexes with other soil types), which is quite rocky (sometimes more than 50% rock content by weight). The Nisqually Series occurs where sand was deposited in eddies during the great floods. Both of these series have a thick, dark A *horizon* due to a high organic matter content, including charcoal created by fires.

Soils formed under forest vegetation (31% of JBLM) are mostly moderately well-drained, occurring primarily on till and moraine. The most widespread forest soil series are the Everett and McChord (16% of JBLM, including complexes with other soil types). These soils have a thinner, lighter-colored A horizon than the grassland soils. McChord soil, occurring on upper slopes and ridge/hill tops, also has a *densic* layer at 40 to 60 inches depth (NRCS 2014).

Wetland soils (2% of JBLM) are characterized by very high organic matter content and are poorly drained. Often, a layer of peat (partially decomposed organic matter) is present.

Freely drained soils (1% of JBLM) occur along the Nisqually River. These are *alluvial* deposits of sand, gravel, pebbles, and *cobbles*.

HYDROLOGY

Year-round surface water is found in 102 lakes/ponds and the Nisqually River; surface streams, however, are uncommon (Figure 6). Wetlands are abundant (nearly 1,000 mapped to date, covering 3,850 acres), both *lacustrine* (mainly along the Nisqually River) and *palustrine* (uplands).

Figure 5. Soils of Joint Base Lewis-McChord.

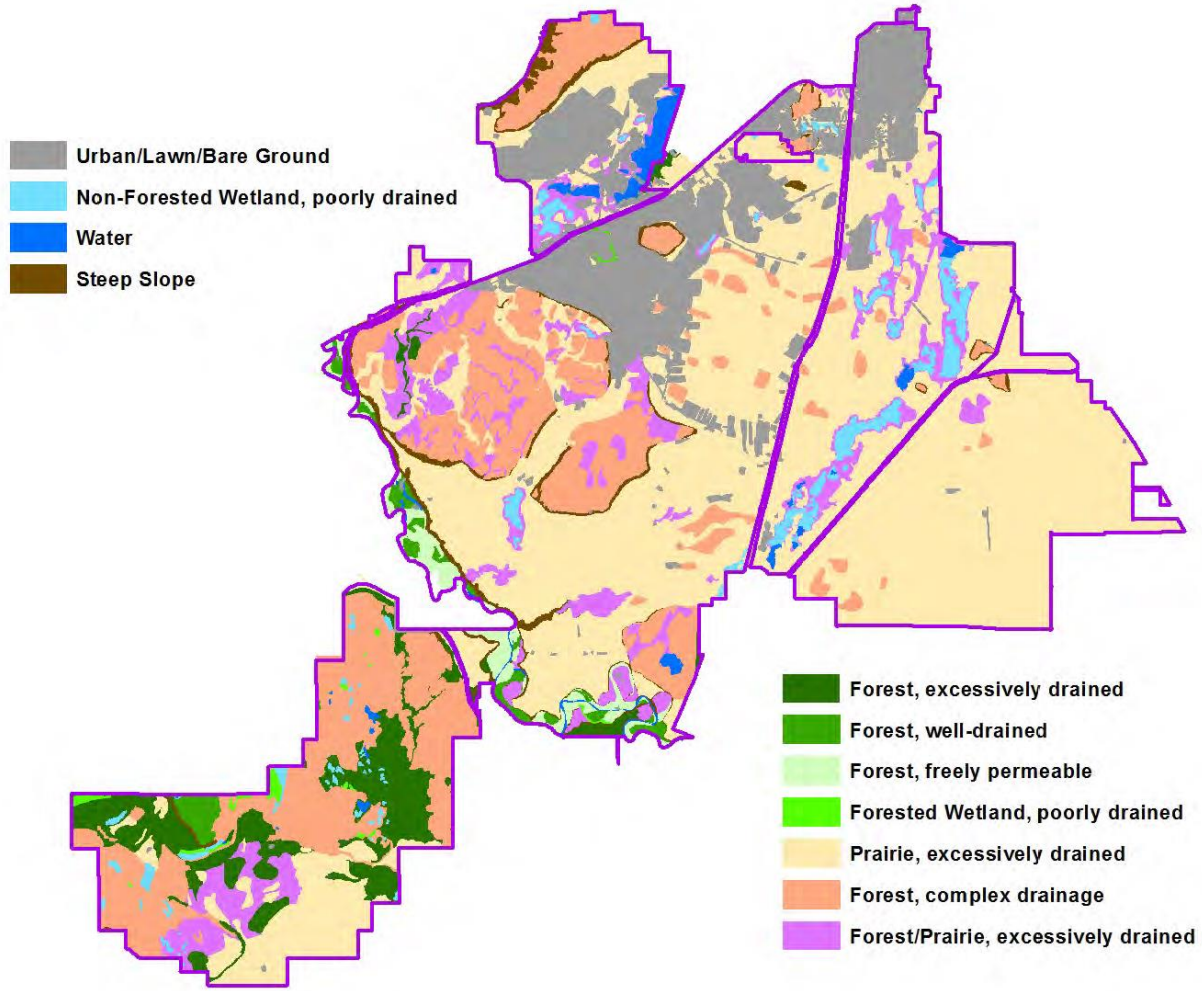
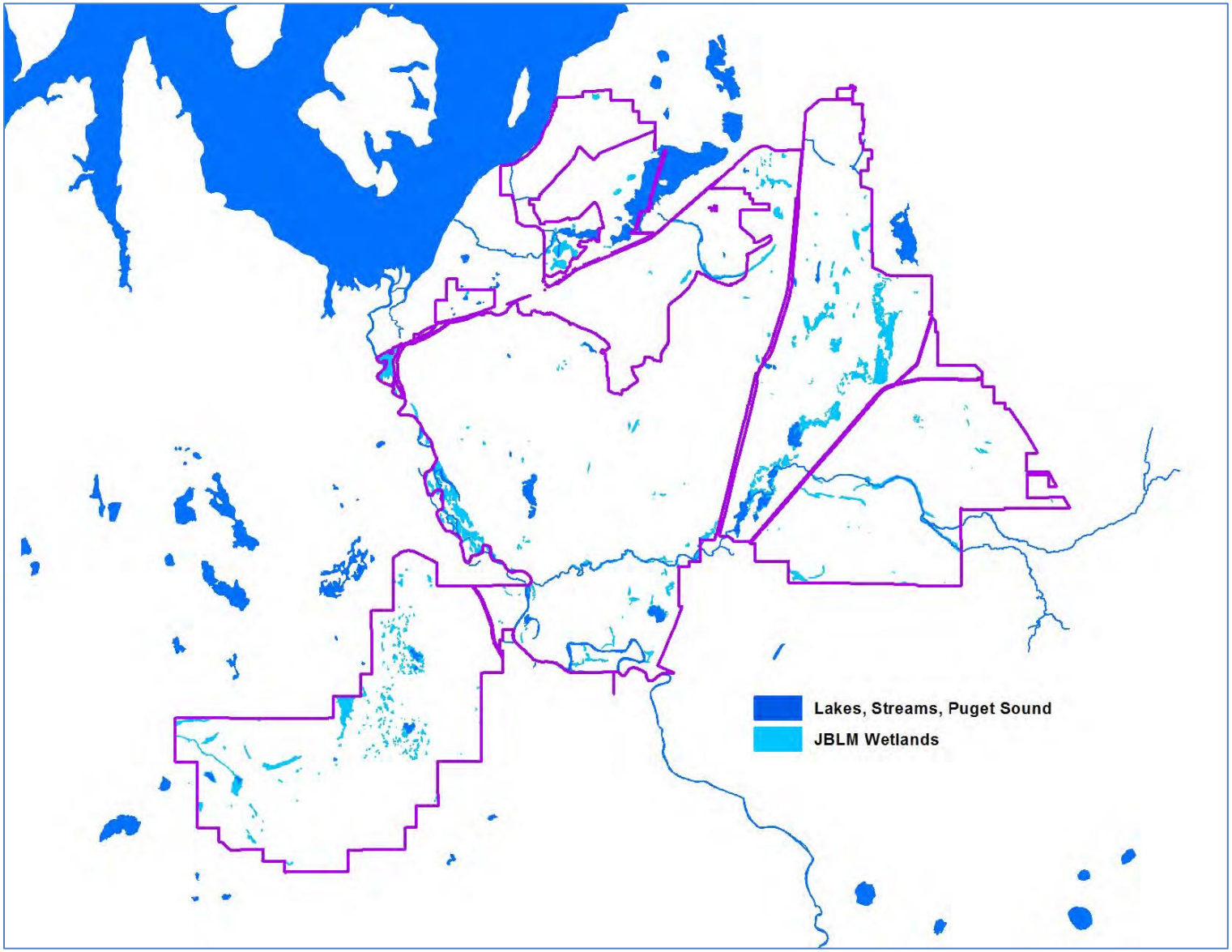


Figure 6. Wetland, lakes, and streams on Joint Base Lewis-McChord.



Groundwater hydrology is complex due to the deep glacial deposits that vary in thickness and texture, both horizontally and vertically. A shallow, *unconfined aquifer* underlies most of JBLM, at a depth averaging 30 feet. In addition, there are deeper *confined aquifers*. Most groundwater north of the Nisqually River flows southwesterly towards the river, whereas groundwater south of the river flows northwesterly. The confined aquifers are the sources of springs where intercepted by the ground surface, especially along the bluffs above the Nisqually River valley.

FOREST VEGETATION

Natural Vegetation

Classification

Vegetation of the Fort Lewis portion of JBLM has been mapped using remote sensing: aerial photos, satellite imagery, and LiDAR (light detection and ranging) data (Chastain 2007), and of the McChord portion using just aerial photos (Figure 7). This mapping follows the National Vegetation Classification System (NVCS; Federal Geographic Data Committee 2008) and the wetlands classification of Cowardin et al. (1985). The NVCS uses a combination of *physiognomy* (physical structure) and *floristics* (species composition) to create a hierarchy of vegetation classification based on plant species composition, plant cover, and vegetative structure.

The first level in the hierarchy is Physiognomic Class, based on the large-scale structure of vegetation: closed forest (≥ 60% *canopy cover*), woodland (≥ 25% and ≤ 60% canopy cover), savanna (5-25% canopy cover), shrubland (< 5% tree cover and ≥ 25% shrub cover), grassland (< 5% tree cover and < 25% shrub cover), bare ground, urban (developed), and open water. As shown in Table 2, 24% of JBLM is grassland (including temporary shrubland) and 63% is forest (closed forest, woodland, savanna).

Between the Physiognomic Class and Subclass levels, the NVCS hierarchy has been modified to fit the situation in the forests of JBLM (Table 3). The forests, woodlands, and savannas are divided into Ecological Forest Types, a classification developed specifically for JBLM. Historic moist forests occur in areas that were historically forested (i.e., since before Euro-American settlement) on moderately drained to moderately well-drained soils, mainly on till and moraine, and occupy approximately 18,000 acres (Table 6). Western hemlock and western redcedar co-occur with Douglas-fir in these forests, and red alder often dominates early succession. Historic dry forests occur in areas that were historically forested, but on excessively drained soils on till, moraine, and unconsolidated *glacial drift*, and occupy approximately 9,000 acres. Douglas-fir is the dominant overstory species, with little occurrence of western hemlock and western redcedar, and no red alder. Prairie colonization forests are first-generation conifer stands on former grassland, underlain by excessively drained soils that formed under grassland vegetation, and occupy approximately 33,000 acres. These forests consist exclusively of Douglas-fir, sometimes in mixture with ponderosa pine. Forested wetlands (≈ 1,200 acres) occur in riparian zones and around wetlands; tree species include hemlock, cedar, Oregon ash, and Oregon white oak.

JBLM's historic dry forests are structurally and functionally similar to other locations in western Washington and Oregon where Douglas-fir may be the climax species (Ahrens 1998). The main occurrences of these sites are in the foothills surrounding the Willamette River Valley and on steep, south-facing, thin-soil sites in the Willamette, Mount Hood, Gifford Pinchot, and Olympic National Forests (Ahrens 1998). Small patches of prairie colonization forest occur throughout the

Figure 7. Vegetation of Joint Base Lewis-McChord.

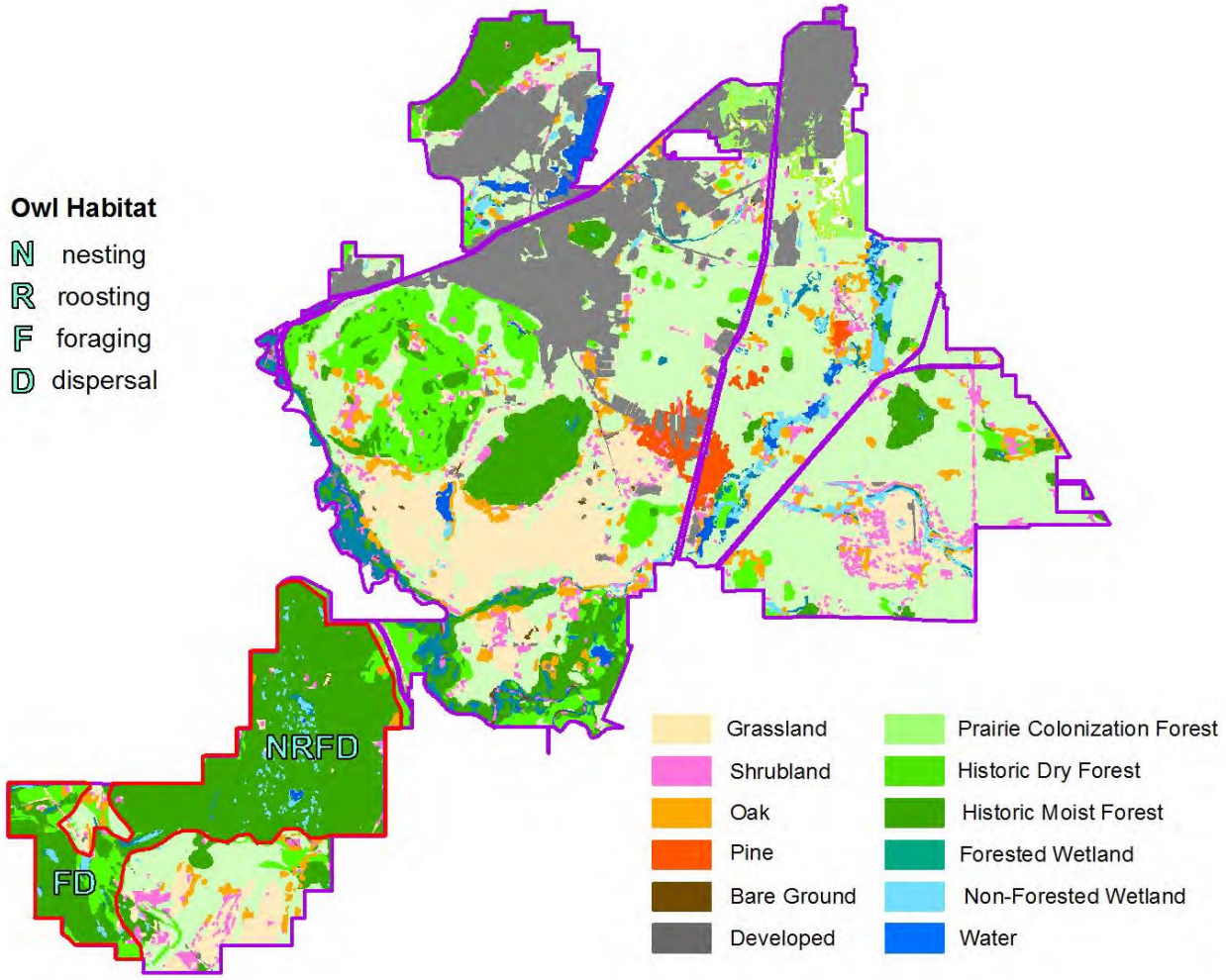


Table 3. Joint Base Lewis-McChord vegetation classification. Items in brackets are the equivalent National Vegetation Classification System definitions.

Forest – 60-100% tree cover [Physiognomic Class: closed tree canopy]

- Moist (MF) – >10% of tree cover is western hemlock, western redcedar and/or red alder *or* western hemlock or western redcedar is the dominant regeneration (>30 stems/acre <5" dbh)
  - Conifer – >75% of tree cover is conifers [Subclass: evergreen forest; Group: temperate needle-leaved evergreen]
  - Hardwood – >75% of tree cover is hardwoods [Subclass: deciduous forest; Group: temperate cold-deciduous]
  - Mixed – 25-75% of tree cover is conifers, the rest hardwoods [Subclass: evergreen or deciduous forest; Group: mixed needle-leaved evergreen or cold-deciduous]
    - Non-oak – 25-75% of tree cover is non-oak/non-madrone hardwoods
    - Madrone – >20% of tree cover is madrone
  - Plantations – Conifer, Hardwood, or Mixed [any subclass or group; Subgroup: planted/cultivated]
- Dry – 0-5% of tree cover is western hemlock, western redcedar, and/or red alder
  - Historic dry (DF) – occurs on forest soils
    - Conifer – >75% of tree cover is conifers [Subclass: evergreen forest; Group: temperate needle-leaved evergreen]
    - Hardwood – >75% of tree cover is hardwoods [Subclass: deciduous forest; Group: temperate cold-deciduous]
    - Mixed – 25-75% of tree cover is conifers, the rest hardwoods [Subclass: evergreen or deciduous forest; Group: mixed needle-leaved evergreen/cold-deciduous *or* evergreen broadleaf]
      - Non-oak – 25-75% of tree cover is non-oak/non-madrone hardwoods
      - Oak – 25-75% of tree cover is oak
      - Madrone – >20% of tree cover is madrone
    - Plantations – Conifer, Hardwood, or Mixed [any subclass or group; Subgroup: planted/cultivated]
  - Prairie colonization (DP) – occurs on prairie soils
    - same classes as for historic dry

Woodland – 25-60% tree cover [Class: open tree canopy]

- Conifer – >75% of tree cover is conifers [Subclass: evergreen open tree canopy; Group: temperate needle-leaved evergreen]
  - Douglas-fir – <10% of tree cover is ponderosa pine or hardwood (oak or non-oak)
  - Ponderosa pine – <25% of tree cover is Douglas-fir or hardwood (oak or non-oak)

Ponderosa pine/Douglas-fir – 25-75% of tree cover is ponderosa pine

Douglas fir-oak – >75% of tree cover is Douglas-fir, remaining 10-25% of tree cover is oak

Douglas fir-non-oak – >75% of tree cover is Douglas-fir, remaining 10-25% of tree cover is non-oak hardwood

Hardwood – >75% of tree cover is hardwoods [Subclass: deciduous open tree canopy; Group: temperate cold-deciduous]

Oak-dominant – >75% of tree cover is oak

Non-oak hardwood dominant – >75% of tree cover is non-oak hardwood

Mixed – 25-75% of tree cover is conifers [Subclass: evergreen or deciduous open tree canopy; Group: mixed needle-leaved evergreen/cold-deciduous]

Mixed (Douglas-fir/oak) – >75% of tree cover is Douglas-fir, remaining 25% is oak

Mixed (oak/Douglas-fir) – 25-75% of tree cover is oak, remaining 25-75% is Douglas fir

Mixed (non-oak/Douglas fir) – 25-75% of tree cover is non-oak hardwood, remaining 25-75% is Douglas fir

Mixed (non-oak/ponderosa pine) – 25-75% of tree cover is non-oak hardwood, remaining 25-75% is Ponderosa pine

Mixed (ponderosa pine/oak) – >75% of tree cover is ponderosa pine, remaining 25% is oak

Mixed (oak/ponderosa pine/Douglas-fir) – unspecified mixture of oak, Douglas-fir, and ponderosa pine

Note: each of the woodland types is further subdivided into Moist, Historic Dry, and Prairie colonization

Savanna – 5-25% tree cover [Physiognomic Class: shrubland or herb dominated; Subclass: evergreen or deciduous shrubland/perennial or annual graminoid; Group: temperate grassland with a sparse tree layer]

Conifer – >75% of tree cover is conifers

Douglas-fir – >75% of tree cover is Douglas-fir

Ponderosa pine – >75% of tree cover is ponderosa pine

Hardwood – >75% of tree cover is hardwoods

Oak – >75% of tree cover is oak

Non-oak hardwood – >75% of tree cover is non-oak hardwood

Mixed – 25-75% of tree cover is conifers

Mixed (oak/Douglas-fir) – 25-75% of tree cover is oak, remaining 25-75% is Douglas-fir

Mixed (non-oak/Douglas-fir) – 25-75% of tree cover is non-oak hardwood, remaining 25-75% is Douglas-fir

Mixed (oak/ponderosa pine/Douglas-fir) – unspecified mixture of oak, Douglas-fir, and ponderosa pine

Note: each of the woodland types is further subdivided into Moist, Historic Dry, and Prairie colonization

Wetland – seasonally or permanently saturated soil [Physiognomic Class: closed or open tree canopy, shrubland, or herb dominated]

Palustrine – >30% total vegetation cover

Forested – >25% tree cover [Physiognomic Class: open or closed tree canopy; Subclass: evergreen or deciduous forest; Group: needle-leaved evergreen, cold-deciduous, or mixed]

Non-riparian – not associated with floodplains

Riparian – associated with floodplains

Hardwood – >75% of tree cover is hardwoods

Mixed – 25-75% of tree cover is conifers, the rest hardwoods

southern Puget Lowland on glacial outwash soils, but JBLM possesses the largest stands and greatest acreage of this ecological type. In fact, we are probably the only ownership in western Washington where there is enough prairie colonization forest to have need of a *silvicultural* approach specific to this type of forest.

Each Ecological Type is divided into one of three Forest Types: conifer (75% or greater total canopy cover is conifer species, hardwood (75% or greater total canopy cover is hardwood species), and mixed (conifers and hardwoods each 25% or greater total canopy cover).

Each Forest Type is divided into Formations, based on overstory species composition. These are various combinations of coniferous and hardwood species. In addition, wetlands are divided into forested and non-forested formations. Forested wetlands are all palustrine.

The finest scale of resolution for vegetation is Plant Association, which has not been mapped across JBLM. Guides to upland and wetland associations for the Puget Lowland uplands are found in Chappell (2005) and Kunze (1994), respectively, and a guide has been developed from these sources that is specific to JBLM (Foster 2015).

Oak and Pine Stands

More forest, woodland, and savanna with a significant component of Oregon white oak (*Quercus garryanna*) occur on JBLM than anywhere else in the Puget Lowlands, a total of about 3,900 acres (Figure 7). Of these acres, about one-third is dominated by oak in the overstory. The majority of oak occurrences are at *ecotones* between closed conifer forest and grassland. Significant oak stands also occur as isolated stands within grasslands, especially on bluffs, and at the margins of wetlands (Foster 2009). Four distinct oak cover types are recognized: oak savanna, oak-dominant, oak-conifer, and conifer-oak (Chappell et al. 2000). Where oak occurs at the edges of wetlands, it is often intermixed with Oregon ash (Foster 2009).

Land survey records from the mid-19th century indicate that, prior to Euro-American settlement, oak was more widespread on JBLM and there was a higher proportion of oak savanna than today (Public Forestry Foundation 1995: Appendix C). On JBLM, as elsewhere throughout most of the range of Oregon white oak, substantial oak habitat has been lost to habitat destruction and to invasion of oak stands by Douglas-fir (*Pseudotsuga menziesii*) in the absence of Native American burning (Thysell and Carey 2001). The invading Douglas-fir grow faster than the oaks, *overtopping* and shading out the oaks, which become suppressed and eventually die.

Oak communities are obligate or preferred habitat for several wildlife species, including the western gray squirrel (see below), acorn woodpecker (*Melanerpes formicivorus*), and slender-billed white-breasted nuthatch (*Sitta carolinensis* var. *aculeata*). The last two species were seen on JBLM in 2015, the first time since they were believed to have been locally *extirpated* (Altman and Stephens 2012). WDFW recognizes oak communities as a Priority Habitat requiring special conservation measures in Washington (Larsen and Morgan 1998). Oregon white oak communities in Washington are classified as G1 (globally critically imperiled) or G2 (globally imperiled) by NatureServe (2012b).

The Fort Lewis Oak Woodland Management Plan (GBA Forestry 2002) established the following goals, now incorporated into this plan, for oak management:

- Maintain and protect remaining high-quality oak habitats to prevent further deterioration.

- Prevent loss of oaks from habitats where oak mortality is imminent without management intervention.
- Prevent decline of oaks due to conifer encroachment and enhance the oak component across all oak types not covered by the above two goals.
- Increase the total acreage and proportions of oak-dominant communities by conversion from oak-conifer communities.

Unique to JBLM is the largest occurrence (approximately 5,300 acres, including some trees just outside the JBLM boundary) of native ponderosa pine west of the Cascade Mountains (Figure 7). There are no other occurrences in western Washington, but numerous small stands are found in the Willamette Valley. Westside pine is genetically distinct from pine east of the Cascades, the former belonging to *P. ponderosa* var. *ponderosa* and the latter to *P. ponderosa* var. *scopulorum* (Potter et al. 2013, 2015). Ponderosa pine was present on JBLM at the time of Euro-American settlement, with its center of distribution being in the vicinity of the Central Impact Area. About 856 acres of JBLM's pine occurrence is dominated by pine, including a unique plant community found nowhere else in the world: ponderosa pine with native grassland understory (Foster 2008). This community is classified as G1 (globally critically imperiled) by NatureServe (2012a). The understory is dominated by *graminoids*, primarily Roemer's fescue, and native *forbs*.

JBLM Forestry and Fish & Wildlife have been conducting ecological restoration of oak- and pine-dominated communities since the mid-1990s (Foster 2008, 2009). Treatments have been various combinations of commercial timber harvest (to remove invading Douglas-fir), pre-commercial thinning (to remove dense stands of young Douglas-fir and reduce stem density of young pine and oak stands), brush mowing, prescribed fire, and native tree and shrub planting.

Old-Growth Stands

Old-growth forest is rare in the Puget Sound lowland. There are two such stands on JBLM, the largest being 59-acre Ellsworth Woods, which lies along Muck Creek in the Artillery Impact Area. The stand is about equally split between uplands and riparian terraces/moist coves, underlain by the Everett-Spanaway-Spana soil complex. The upland portion of the stand is prairie colonization forest. The oldest tree cohort is Douglas-fir more than 400 years of age and up to 75 inches dbh and 215 feet tall (Ahrens 1998). Large dead wood is abundant.

One other, approximately 4.5-acre old-growth stand occurs at the west end of Bennett Hill in the Central Impact Area. This is historical moist forest on McChord-Everett soil. The *overstory* is a mixture of Douglas-fir, hemlock, and cedar, with an estimated maximum age of 200 years. There are also a number of stands that are not old growth, but contain scattered *legacy* Douglas-fir, typically 150 years of age or older with charred bark near the base from past forest fires. These stands occur in the Central Impact Area and along the steep bluffs above Puget Sound and either side of the Nisqually River.

Minor Tree Species

Lodgepole pine (*Pinus contorta*) occurs as small stands or isolated trees in two types of habitats: (a) wetlands, primarily on isolated hummocks above the water table, and (b) grasslands, both at ecotones with conifer forest and out in the open. There is a significant amount of madrone (*Arbutus menziesii*), primarily on forested ridgetops previously subject to fire, the steep bluff above Puget Sound, and scattered locations in grasslands and prairie colonization forests. The

largest (42 acres) single stand of madrone is in the North Impact Zone. Sitka spruce (*Picea sitchensis*) is limited to four occurrences, one in Training Area 16 and three in the RTA; the largest occurrence is an 82-acre stand in Training Area 22. Grand fir (*Abies grandis*) grows on the Nisqually floodplain in Training Area 19 (some of these trees are 200 feet tall) and adjacent to the spruce stand in Training Area 19. Quaking aspen (*Populus tremuloides*) is rare in the southern Puget Lowlands; there are four clonal clumps on JBLM.

Rare Plants

A federally-listed plant, water howellia (*Howellia aquatilis*), occurs in 23 wetlands within the forested areas of JBLM (Figure 3). Military training is prohibited in wetlands, and wetland buffer zones minimize forest management impacts on wetlands, so howellia habitat is secure.

Small-flowered trillium (*Trillium parviflorum*) is a state sensitive plant species that grows in moist oak woodlands on JBLM. Populations of this species were located and mapped during 1997 and 2017 surveys. The majority of these populations are located in *Seibert-staked* areas and thus protected from vehicle training.

The northernmost, and only Washington, occurrence of pine-foot (*Pityopus californica*), a state-listed threatened plant, is in conifer forest in the Rainier Training Area, but it has not been observed there since 1997.

Invasive Plants

Invasive plants in JBLM's forests fall into two categories: native invaders and non-native invaders. On JBLM, the primary native invader is Douglas-fir, which, in the absence of fire since the mid-1800s, has been colonizing former grasslands to create prairie colonization forest (Foster and Shaff 2003). Non-native invasives originate from other geographic locations, primarily Europe. Most were first brought, deliberately or accidentally, by settlers (see Section 7.1).

SPECIES OF CONCERN

Scotch Broom

Scotch broom (*Cytisus scoparius*) is a non-native, evergreen, *leguminous* shrub that is native to northern Europe and Britain. It arrived in the Pacific Northwest in the 1890s, and in recent decades has become a major invasive plant in open areas. This shrub has deciduous leaves and evergreen photosynthetic stems, rapid growth (up to three feet per year), abundant seeds that remain viable in the soil for decades, and the ability to sprout back from the base of the stem if the aboveground portion of the plant is killed. As a legume, it has root nodules with bacteria that can remove nitrogen gas from the air and convert it to ammonia, a form of nitrogen that plants can use as a nutrient when it occurs in soil. Mature broom plants can form dense *monocultures* 6-10 feet tall.

Broom thrives wherever there is sufficient sunlight reaching the ground, such as in clearcuts, *shelterwood* stands, and heavily-thinned stands (Harrington 2007); a good rule of thumb for the risk of broom colonization is areas where canopy cover is less than 50%. In JBLM forests, broom is likely to occur in clearcuts, *canopy gaps*, logging *landings*, and along roads. Broom seed has been spread to almost every corner of JBLM, primarily by military vehicle movement;

natural dispersal is quite slow (Parker and Reichard 1997). Many plantations established since the 1980s have failed because of dense broom outcompeting planted conifer seedlings.

Typically, a combination of mechanical, chemical, and prescribed fire treatments is used to kill adult plants in southern Puget Lowland grasslands, force germination of dormant seed, and kill the germinants. The long-term goal is to gradually exhaust the soil *seed bank.*

For six years, JBLM Forestry funded research into control methods for broom in failed conifer plantations. Field experiments compared effectiveness of broom control for various combinations of mechanical and chemical broom removal, applied before or after conifer tree planting, and repeated one to several times. The results indicate that herbicide use (e.g., Garlon) is highly effective at killing Scotch broom, regardless of time of year, and is consistently more effective than mechanical control alone (Parker et al. 2014).

Scotch broom has three negative effects on training:

- Inhibits military training – Broom forms dense thickets, up to 10 feet tall, that inhibit movement of troops and vehicles, and impede visibility.
- Increases fire danger – Broom is highly flammable and rapidly increases fuel loads.
- Eliminates native grassland – Broom outcompetes native grassland plants. Its shade prevents germination of grassland plants from seed and aboveground growth from *bulbs* and *rhizomes*. It may also alter soil chemistry such that tree and native grassland plant growth is inhibited.

Himalaya and Evergreen Blackberry

Himalaya blackberry (*Rubus armeniacus*) and evergreen blackberry (*Rubus laciniatus*) are native to Eurasia. Like Scotch broom, they are capable of growing wherever overstory tree cover is less than 50%. Himalaya blackberry forms dense, impenetrable thickets. It tolerates a wide range of soil conditions, including coarse-textured soils with low *water-holding capacity*, which are common at JBLM (Caplan and Yeakley 2006).

On grasslands, both species outcompete native grassland plants, while in forests, both species outcompete native *understory* shrubs and ground cover. Both blackberry species outcompete tree seedlings in plantation settings, as well as present an obstacle to troop movement. Control necessitates mechanical removal, followed by herbicide application, and must usually be repeated.

English Ivy and English Holly

English ivy (*Hedera helix*) is native to northern Europe and Britain. It is a *shade-tolerant, clonal* species that spreads by surface runners. While on the ground, it does not produce fruits. However, once it climbs a tree, fruits will eventually be produced and dispersed by birds. In JBLM's forests, ivy seldom accumulates to the extent that it kills mature trees, but it outcompetes native understory ground cover, eventually completely displacing it.

Ivy control was initiated on JBLM in 2013. Ivy on trees is controlled either by cutting off stems at the base of the trunk and either pulling the roots of small stems out of the ground or applying herbicide to the cut stumps of large stems. Ivy on the ground is controlled by hand-pulling plants

out of the ground, roots and all, and piling the pulled plants where they are not in contact with the soil, so they can't re-root.

English holly (*Ilex aquifolium*) is also native to northern Europe and Britain. It is a slow-growing evergreen shrub that grows up to 50 feet tall and can produce thickets via *layering* and *suckering* from the base of the stem. It spreads when birds ingest the berries and the undigested seeds are deposited elsewhere in their droppings. This species excludes native shrubs and herbs wherever it grows. Herbicide applied to cut stems or injected into intact stems is the typical method of control.

Periwinkle, St. John's Wort, and Archangel

Common periwinkle (*Vinca minor*) has been found at six locations on JBLM, creeping St. John's wort (*Hypericum calycinum*) at one location, and yellow archangel (*Lamiastrum galeobdolon*) at three locations. Periwinkle patches are partly holdovers from historical homesteads and partly due to long-distance transport of seeds by birds. Creeping St. John's wort and archangel patches are probably due to bird transport. Like English ivy, these three species spread clonally across the ground, eventually replacing native ground cover.

Control of these species was initiated in 2013 by means of herbicide foliar spraying, and is being to be repeated two or more times in subsequent years to attain complete control.

Noxious Weeds

Noxious weeds are specific, non-native plant species that are toxic to animals, and many of which, by law, must be controlled by landowners, including the Federal government. The JBLM Fish & Wildlife program and the Integrated Training Area Management (ITAM) program in Range Support jointly control Class A (highest priority) weeds and some Class B (lesser priority) weeds, for which each county maintains a list, primarily using herbicides. None of these weeds has affected more than a tiny fraction of the forested landscape, but some are such aggressive invaders that prompt control is necessary to prevent their spread.

Knotweeds (*Polygonum* spp.) from Asia occur in the Nisqually River floodplain and occasionally in moist, upland forests on JBLM. They grow rapidly, spread clonally from rhizomes, and can root from stem and root fragments. They are a high priority for control.

Of particular concern is spurge laurel (*Daphne laureola*); five infestations have recently been discovered at JBLM, one in the cantonment, one in Training Area 4, and several in the eastern training areas. This shade-tolerant, clonal shrub is poisonous and causes contact dermatitis (severe skin rash). The cantonment infestation was removed in 2016, and plans are being made for further, aggressive control in the training areas.

DEAD WOOD

Coarse woody debris (CWD) is dead wood consisting of *snags* and logs, with an average diameter (breast-height for snags, midpoint for logs) on JBLM of at least 10 inches. Snags occur in four decay classes, ranging from recently dead (bark, branches, and twigs still present) to highly decayed (no bark or branches, trunk partially gone, broken off not far above the base). Logs occur in five decay classes, ranging from freshly fallen live trees or recently-dead snags to logs so decayed they are merging with the forest floor.

CWD serves multiple roles in the structure and function of forest ecosystems, including nutrient and water storage, organic matter buildup in the soil, and habitat for a variety of organisms. Most of JBLM's forests are deficient in CWD compared to their natural forest counterparts (Foster 2009). During logging operations, snags are not cut unless they pose a hazard to the loggers, of if located within 100 feet of roads and troop assembly areas.

FOREST FISH AND WILDLIFE

JBLM's forests provide habitat for numerous wildlife species, including ESA-listed, state-listed, and other special-status species. Management of wildlife populations and habitats is described in the Fish and Wildlife Management Plan, a component of the JBLM INRMP. On-the-ground management of game and non-game wildlife, wetlands, and, in conjunction with Range Support[3], grassland management, is the responsibility of the JBLM Fish & Wildlife Program.

Western Gray Squirrel

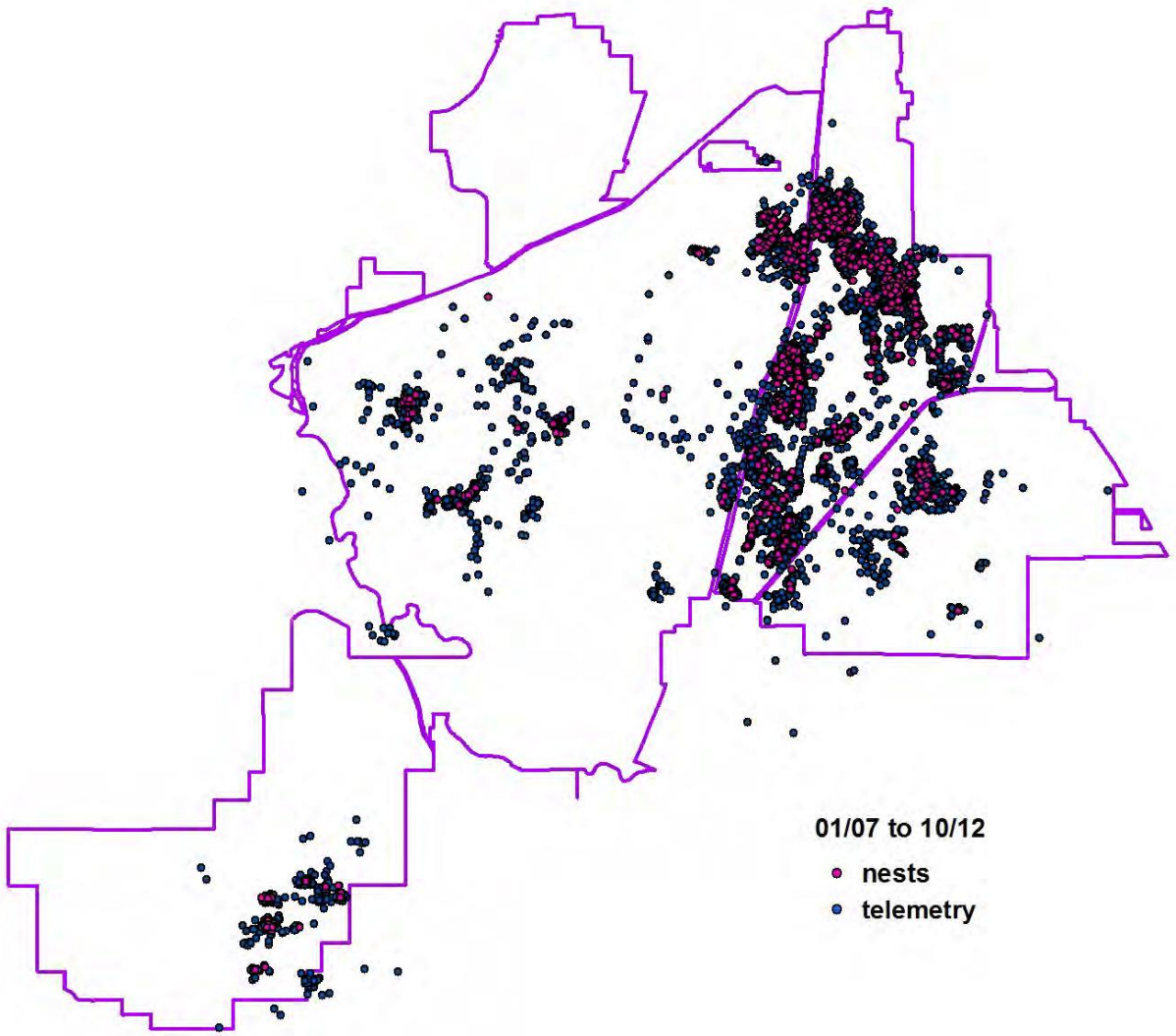
The western gray squirrel (*Sciurus griseus*) is State-listed as threatened. Once widespread in southwestern Washington, there is now only one population in that geographic area, on JBLM. In the 1990s, this population was less than 100 individuals and was restricted to a triangular area encompassing portions of the Central Impact Area and Training Areas 6, 8, 10, and 12 (Ryan and Carey 1995, Bayragki et al. 2001). Today, the JBLM population is growing and extending its distribution across JBLM, the result of habitat restoration and *translocation* of squirrels from the larger populations in eastern Washington since 2007 (Vander Haegen et al. 2007). Squirrels are now found in the Ammunition Storage Point, McChord south approach zone, throughout the Central Impact Area, and in Training Areas 3, 4, 5, 11, 13, 14, 15, 20, 21, and 22 (Figure 8).

Forest stands dominated by dense, even-aged Douglas-fir are still the most common stand type on JBLM. These stands have structural features that are unattractive to western gray squirrels. Western gray squirrels prefer transitional, conifer-dominated areas that merge with open patches of oak and other deciduous trees (Linders et al. 2010). Preferred stands consist of clumps of trees that form a dense upper canopy intermingled within areas of lower canopy cover and small canopy gaps. This structural diversity provides (a) an interconnected canopy for escape cover, nest concealment, and discrete access to nests; (b) thermal protection of nests; (c) sunlight for basking; (d) an abundance of seeds close to canopy gaps; (e) fungal concentrations under closed forest canopies; (f) a fairly sparse understory, except in canopy gaps; and (g) "viewsheds" for predator avoidance (Linders et al. 2010). Conifers greater than 15 inches dbh are important as breeding nest sites. Mature, large-seeded *mast* trees, such as oak and pine, provide abundant food. Seeds and nuts from other trees and shrubs, like beaked hazelnut (*Corylus cornuta*), are also consumed. Habitat connectivity via corridors is essential for mate access, juvenile dispersal, predator avoidance, and movement between habitat patches.

Significant threats to the JBLM squirrel population are habitat loss (from development, logging, road construction, and fire suppression), road-kill mortality, and disease (e.g., mange). Competition from non-native, eastern gray squirrels was recently demonstrated to be small (Johnston 2013).

[3] The JBLM office − part of the Directorate of Plans, Training, Mobilization, and Security − which manages the training lands.

Figure 8. Western gray squirrel distribution on Joint Base Lewis-McChord.



As a result of population growth and translocations, JBLM's squirrel population is re-expanding its geographic range into areas that have been unoccupied for many years. Within occupied squirrel habitat, JBLM Forestry sometimes modifies timber sales to protect or create squirrel habitat, and no logging occurs between March 1 and August 31 when squirrels are actively nesting.

Northern Spotted Owl

The northern spotted owl (*Strix occidentalis caurina*) was listed as threatened under the ESA in 1990. In 1994, most of Fort Lewis was designated as *critical habitat* by the USFWS, although repeated surveys have failed to locate any owls on the installation. As a result, Fort Lewis prepared a Northern Spotted Owl Habitat Management Plan (Bottorff 1994). This plan emphasized ecological forestry practices that would result in the long-term creation of owl habitat. In 2008, the critical habitat designation was lifted, but in 2012, to avoid re-designation, then Fort Lewis completed a USFWS-approved Endangered Species Management Plan (ESMP) for northern spotted owl critical habitat (US Army 2012b), qualifying for an ESA military exemption from critical habitat.

Spotted owls rely on older forests because these contain the structural characteristics required for nesting, roosting, and foraging (US Fish and Wildlife Service 2011). Features that support nesting and roosting typically include moderate to high canopy closure (equal to or greater than 60 percent); a multilayered, multi-species canopy with large (*dbh* greater than 30 inches) overstory trees; a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly. Stands with high canopy closure also provide thermal cover and protection from predators. Foraging habitat generally has attributes similar to those of nesting and roosting habitat, but is unlikely to successfully support nesting pairs. Younger forests can contribute to owl dispersal habitat, which at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities.

The primary prey for the spotted owl in the Washington portion of its range is the northern flying squirrel (*Glaucomys sabrinus*). This species is positively associated with late-successional forests with high densities of large trees and snags. Flying squirrels typically use cavities in large snags as den and natal sites, but may also use cavities in live trees, hollow branches of fallen trees, crevices in large stumps, stick nests of other species, and lichen and twig nests they construct. Fungi are prominent in their diet; seeds, fruits, nuts, vegetation, insects, and lichens are also consumed.

Currently, the most important range-wide threats to the owl are (US Fish and Wildlife Service 2011):

- Competition with barred owls (*Strix varia*) (these owls are present on JBLM).
- Ongoing habitat loss as a result of timber harvest.
- Habitat loss or degradation from stand-replacing wildfire.

To address these threats, the recovery strategy (U.S. Fish and Wildlife Service 2011) has four basic steps:

- Completion of a rangewide habitat modeling tool.
- Habitat conservation and active forest restoration.
- Barred owl management.
- Research and monitoring.

In Westside conifer forests, the USFWS recommends (US Fish and Wildlife Service 2012c):

- Conserve older stands that have occupied or high-value owl habitat.
- Emphasize active management to meet owl recovery goals and long-term ecosystem restoration and conservation.
- Continue to manage for large, continuous blocks of late-successional forest.

Active management for spotted owl habitat has, since 1994, been a major objective of JBLM forest management. The USFWS endorses silviculture as a prime tool for hastening the development of spotted owl habitat in second-growth forests. To quote from US Fish and Wildlife Service (2012c): "In general, silviculture prescriptions that apply ecological forestry principles to address the conservation of broader ecological processes are compatible with maintaining the proposed critical habitat's essential features in the long term" (p. III-14). "Critical habitat for the northern spotted owl is not intended to be a 'hands-off' reserve in the traditional sense. Rather, it should be a 'hands-on' ecosystem management landscape that should include a mix of active and passive actions to meet a variety of conservation goals that support long-term spotted owl conservation" (p. 54). Under the Owl Habitat ESMP, we are now emphasizing silviculture to develop owl habitat within a 17,???-acre Owl Focus Area (Figure 7).

Other Birds

Bald eagles (*Haliaeetus leucocephalus*), protected under the Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668-668c), occur on JBLM, both as year-round residents (10 known nests) and as wintering birds that rely on local salmon runs. Wintering eagles reach abundances of up to 270 individuals, and utilize roost trees along salmon-bearing waterways. JBLM has 800-meter buffer zones around bald eagle nest sites and communal night roosts and 800-meter protection zones either side of foraging habitat along Muck Creek and the Nisqually River (Figure 3). Within these zones, protective measures are in place to avoid adverse impacts to eagles due to logging and military training.

Periodic surveys have not detected the federally threatened marbled murrelet (*Brachyramphus marmoratus*), an old-growth-dependent species, on JBLM.

All potential timber sales are surveyed for *raptor* nests by the JBLM Fish and Wildlife Branch. Trees are not marked for cutting in the vicinity of these nests.

Migratory birds are protected under the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712). DoD has a memorandum of agreement with the USFWS to promote the act's purposes.

Fish

Twenty-five fish species live on JBLM. Federally threatened chinook salmon (*Oncorhynchus tshawytscha*) of the Puget Sound Evolutionary Significant Unit (ESU) have a summer/fall run on the lower Nisqually River. Federally threatened steelhead (*Oncorhyncus mykiss*) belong to the Puget Sound ESU, with both winter and summer runs on the lower Nisqually River. Federally

threatened bull trout (*Salvelinus confluentus*) are occasionally observed in the lower Nisqually River in winter and spring. One other salmonid, the chum (*Oncorhynchus keta*), has a winter run up Muck Creek, a tributary of the Nisqually. No critical habitat for any listed salmonids is designated in JBLM waters.

To reduce impacts to fish, all fording of streams on JBLM during training exercises occurs at hardened crossings to limit disturbance to stream channels. JBLM is a partner with the Nisqually Tribe in restoring in-stream habitat in Muck Creek. On-going conservation actions include removal of invasive reed canarygrass (*Phalaris arundinacea*), cleaning and replacement of gravel in salmon spawning areas, and planting of riparian trees and shrubs to provide shade where the creek crosses open grassland.

Amphibians

The Oregon spotted frog (*Rana pretiosa*) is listed at both the State and Federal levels. The species was last observed on JBLM in 1959, but was reintroduced by WDFW to a single wetland (Dailman Lake on Muck Creek) in Training Area 12 in 2008. Breeding success was verified in 2011, but no egg masses have been found since then. The captive rearing and release of juvenile spotted frogs into Dailman Lake was discontinued in 2016.

The Western toad (*Bufo boreas*), a Federal species of concern, breeds in five permanent water bodies in the RTA. In late spring, the young migrate en masse to nearby forests and grasslands. To protect them during their migrations, a road along the eastern shore of Fiander Lake has been permanently closed, and if migration is observed during logging, cutting may temporarily be moved elsewhere.

Insects

Thes federally-endangered Taylor's checkerspot butterfly requires grassland habitat dominated by native species. Management for this species may affect forest resources on JBLM because it needs diverse microhabitats besides flat grassland, including "diffuse" forest edges that provide protection form the wind, warmer temperatures, and nectar plant species that bloom later into the summer than when located in open grassland (Fimbel 2004).

CULTURAL RESOURCES

There are 956 acres of cultural sites, both pre-historic and historic. The JBLM Cultural Resources Program manages these sites. Prior to Euro-American settlement, Native American camps and villages were located primarily along streams and at grassland/forest ecotones. The Native Americans used fire as a management tool to maintain open conditions and encourage grassland food plants and game animals.

Historic resources begin with the remnants of Fort Nisqually in Dupont, WA, adjacent to JBLM, which was founded by the Hudson's Bay Company in 1832. Subsequently, the Puget Sound Agricultural Company began farming and grazing on JBLM, mostly in grasslands. Later, many pioneer homesteads and cemeteries were established.

Cultural resources on federal lands are regulated by the National Historic Preservation Act (16 U.S.C. §§ 470 *et seq.*), which requires inventory of cultural resources and consultation with State Historic Preservation Offices (SHPOs) prior to finalizing management plans and projects. Native

American cultural resources, including traditional uses, are further regulated by the Native American Graves Protection and Repatriation Act (25 U.S.C. §§ 3001 *et seq*.) and Executive Orders 13007 and 13175. JBLM recognizes tenure and use rights within the "usual and accustomed territories" as delineated by the Federal government for the tribes (Nisqually, Puyallup, Squaxin Island) involved in the 1854 Treaty of Medicine Creek. Collection of forest resources, such as firewood and cedar bark, by tribal members is permitted as long as it does not conflict with military training.

Before any timber sales or other ground-disturbing forest management activities can occur, the Forestry Branch consults with JBLM's Cultural Resources staff, who, in turn, consult with the Washington SHPO. Known cultural sites are off-limits to logging equipment. If loggers discover previously unknown cultural artifacts, they must stop work and immediately notify the USACE that administers JBLM's timber sales.

When a new historic or prehistoric site is found, restrictions are placed on military training and natural resource management to prevent site disturbance, and the sites are *Seibert-staked*. Each year, several known sites are evaluated for eligibility for the National Register of Historic Places. If they are not eligible, training and management restrictions are lifted.

AIR AND WATER QUALITY

Air Quality

Particulate matter in two size classes (PM_{10}, $PM_{2.5}$) is considered a *secondary pollutant* that is generated by prescribed burns and wildfires. There is a $PM_{2.5}$ non-attainment area in southern Tacoma/Parkland/Spanaway, adjacent to JBLM. Non-attainment areas are out of compliance with the National Ambient Air Quality Standards set by the Clean Air Act. There are specific requirements, focused on reducing pollutant emission, imposed on non-attainment areas by the Environmental Protection Agency (EPA).

As a major source of PM_{10}, prescribed burning is regulated by WDNR, from who permission must be granted prior to each burn. During the summer/fall burning season, burn bans are often in place due to high fire danger or poor air quality, although JBLM is exempt from the first type of ban.

Water Quality

JBLM discharges into Puget Sound include surface water, groundwater, effluent from the sewage treatment plant, and runoff from the stormwater collection system. Washington State considers the quality of surface streams, lakes, and wetlands on JBLM to be generally extraordinary or excellent. Only one water body, American Lake, is considered impaired (excess phosphorus). There are also problems with excess water temperature in Muck Creek in unshaded reaches during low flows.

The potential for soil *erosion* and *compaction* is very low across most of JBLM because of flat or gently rolling terrain and highly permeable soils with high rock content. Thus, delivery of sediment (due to erosion) or of excessive *runoff* (due to compaction) to surface water bodies is highly localized and associated with specific events, such as major winter storms or military training, logging, or construction on sensitive soils.

Groundwater quality in the multiple confined and unconfined aquifers that underlie JBLM is also excellent. In general, total dissolved solids are low and dominated by calcium and bicarbonate. With a few exceptions, JBLM's groundwater is pure enough to serve as a drinking water source. In fact, the Central Pierce County Aquifer, which underlies all of the Pierce County portion of JBLM, is designated by the EPA as a sole-source aquifer that provides more than 50% of the drinking water consumed in the area overlying the aquifer.

CHEMICAL USE

Several types of herbicides are used on JBLM to control invasive and non-native vegetation. Chemical use on JBLM is guided by an Integrated Pest Management Plan (IPMP). The Forestry Branch is also preparing its own pest management plan, tied to the IPMP.[4]

Prior to 2013, herbicide use in JBLM's forested areas occurred almost entirely as spot spraying by JBLM Fish & Wildlife to control noxious weeds and conduct ecological restoration. Subsequently, Forestry began increasing herbicide use to combat widespread failure of planted areas due to Scotch broom competition. It became clear that the broom problem was so pervasive that the only way to reduce it to more manageable levels, and to facilitate adequate growth of new trees following timber harvest, was to use herbicides. As broom levels become more manageable, herbicide use will decrease and there will be more reliance on non-chemical methods to keep the remaining broom in check.

Currently, Forestry uses herbicides to control unwanted vegetation, primarily Scotch broom and native brush, in three locations:

(1) Along paved roads and major dirt roads. Depending on the road, this is accomplished by the Pest Management Shop in Public Works, the ITAM program, or JBLM Forestry.

(2) In logging landings, to facilitate replanting or to keep them brush-free until used in the next logging operation. This is carried out by JBLM Forestry.

(3) In plantations and any other areas where artificial regeneration is used, to reduce brush competition with tree seedlings. This is also a JBLM Forestry responsibility. Working with ITAM, Forestry may soon initiate herbicide control of brush at military firing points.

Herbicide use also occurs during ecological restoration activities, primarily to control Scotch broom and non-native, invasive grasses. Most such use is on grasslands, but there is occasional use in oak- and pine-dominated stands as part of ecological restoration projects carried out by JBLM Forestry and Fish & Wildlife. Forestry also uses herbicides to control invasive, non-native, forest understory plant species (English ivy, English holly, periwinkle, archangel). Fish & Wildlife and ITAM conduct annual spot applications of herbicides to control noxious weeds and aggressive non-native grasses, primarily in grasslands but occasionally in forests.

All herbicide use must go through an Army approval process.[5] The use of certain chemicals of high toxicity and persistence (e.g., *chlorinated hydrocarbons*) is prohibited in most forested

[4] The IPMP meets the requirements of DoD Instruction 4150.07 (Department of Defense 2013), Army Regulation 200-1, and AFI 32-1053 (US Air Force 2014).

[5] DA Pam 710-7 (US Army 2013) and Army IPM policy state that pesticides have to be approved by Army Environmental Command and JBLM Pollution Prevention.

portions of the training areas to comply with an FSC list of banned herbicides, and thus to maintain JBLM's sustainable forest certification.

No spraying for insects (e.g., mosquitoes, tussock moth) occurs in JBLM's training areas. However, treatment could occur if Asian gypsy moths are detected. No pesticides are used to kill rodents and other unwanted animals on JBLM's training areas outside of the cantonment.

Herbicide application is done by Forestry personnel, contractors, and the non-profit Center for Natural Lands Management, which has a cooperative agreement with JBLM.[6]

RECREATION

Outdoor recreation is permitted at certain times and places in the JBLM training areas.[7] The Outdoor Recreation Program manages the hunting and fishing programs on JBLM, maintains designated facilities, and rents equipment. Range Support issues training area access permits, when required, for recreational activities.

Most waters on JBLM are open to fishing and boating by DoD personnel civilians, and tribal members exercising their treaty fishing rights, with the exception of Nisqually Lake in the Artillery Impact Area and Muck Creek where it flows through the Artillery and South impact areas. Hunting consists of four main types: big game (deer, bear), waterfowl, upland game birds (pheasant, grouse, partridge), and small game. For the most part, all training areas on JBLM are open to hunting (subject to availability, which depends on military training), with the exception of Close-in Training Area F, the Artillery/South/Central impact areas, and several lakes and wetlands.

Under FL Regulation 350-30, all recreational vehicular traffic is restricted to established roads. Therefore, off-road vehicle use is not an authorized form of recreation on JBLM.

Few data exist for recreational use of JBLM. Area access permits issued by Range Support indicate that the major recreational uses are, in order of popularity: hunting, fishing, horseback riding, hiking, and dog training (Resource Dimensions 2012). Other known uses are nature study and mountain biking. Primitive camping is allowed at Lewis Lake and Chambers Lake.

SOCIAL AND ECONOMIC ENVIRONMENT

The primary Region of Influence (ROI) for JBLM Forestry is Pierce and Thurston counties. Most timber-sale bidders are from these counties, although some are located elsewhere in western Washington. Most recreational users are residents of these counties or are stationed at JBLM.

Stakeholders

Internal stakeholders are:G

- Garrison staff – Those civilian employees and military personnel responsible for management of JBLM's training lands.

[6] Pesticides are applied in accordance DODM 4150.07 (Department of Defense 2013).

[7] Fort Lewis Regulation 215-1 (US Army 2005) governs hunting, fishing, and camping, while other outdoor recreation activities are governed by Fort Lewis Regulation 350-30 (US Army 2000).

- Soldiers – Soldiers stationed at JBLM and soldiers from units elsewhere that visit JBLM to conduct military training.

External stakeholders are:

- Forestry contractors **–** This category includes those who work directly in the forest, (e.g., loggers, tree planters, brush control). It also includes researchers and organizations conducting work in the forest.
- Forestry- and recreation-related businesses and industries – This category includes those processing forest products from the installation (i.e., sawmills), selling products used in harvesting forest products on the installation, or selling retail goods used in recreation activities in the installation's forest.
- Communities – Towns and cities adjacent to JBLM that may be affected by forest management activities: DuPont, Lacey, McKenna, Olympia, Parkland, Roy, Spanaway, Steilacoom, Tacoma, Tumwater, and Yelm.
- Adjacent landowners **–** This category is comprised of those owning land immediately bordering JBLM.
- Indian tribes **-** Tribal access to traditional (usual and accustomed) hunting and fishing grounds, and other areas important to the continuation of tribal culture, within the boundaries of JBLM.

Consultation on forest management activities with internal stakeholders occurs on a frequent basis. The primary mechanism is *deconfliction*, a process, managed by the Public Works National Environmental Policy Act (NEPA) staff, whereby potential projects in the training lands and the cantonment are vetted by a wide range of JBLM staff before they are finalized and committed to. On a regular basis, NEPA staff schedule deconfliction meetings and invite a wide variety of internal stakeholders to attend. Training lands projects for consideration are submitted to the Range Officer (head of Range Support), who arranges for them to receive deconfliction.

Consultation with external stakeholders consists primarily of sharing of information, and sometimes sit-down meetings, with Indian tribes that have treaty rights on JBLM. The Forestry Branch also conducts occasional timber-sale bidder surveys.

Forest Management Activities: Social Effects

The following forest management activities have potential social effects within the ROI: commercial harvest, reforestation and *timber stand improvement*, wildfire and prescribed burning, ecological restoration, commercial and non-commercial firewood harvest, and recreational use.

In a telephone survey, no respondents reported negative effects of forest management activities on archeological sites or sites of community, cultural, or historic important (Resource Dimensions 2012). Respondents' comments concerning the effect of forest management activities on food gathering and water quality were generally positive. Impacts to air quality and aesthetics from prescribed burning were discussed by a number of respondents, typically with a negative connotation. Respondents noted a range of positive and negative impacts due to recreational use.

Most respondents indicated that community goals for forest and natural resource use and protection were not negatively impacted by forest management activities (Resource Dimensions

2012). Comments were generally positive regarding timber harvesting, reforestation, and ecological restoration activities. Most respondents indicated that they believe JBLM's forest management has no effect on local economic opportunities; yet, a few respondents commented that timber harvesting and other recreational uses help increase the economic diversity of the socioeconomic ROI.

Forest Management Activities: Economic Effects

Harvesting of secondary forest products (e.g., brush) on JBLM is permitted for personal use only, so only the wood products portion of the forest products industry has a stake in JBLM's forests. A survey of JBLM timber sale bidders (Resource Dimensions 2012) showed that the majority has gross sales between $1 million and $5 million. These bidders prefer *scaled sales* to *lump-sum sales*, larger sales to smaller sales, and sales spaced throughout the year rather than concentrated in particular seasons (Table 4). Seventy percent of these bidders purchase more than one million board feet (MMBF) of FSC-certified wood annually. Most of JBLM timber bought by bidders is FSC-certified.

Table 4. Buying preferences of JBLM timber-sale bidders.

Question	Response	Answers (%)
Scale or lump sum sales?	Scale sales	50
	Lump sum sales	15
	No preference	35
Optimal volume of sale at current stumpage prices?	Less than 50 MBF[1]	10
	51 to 200 MBF	5
	201 to 500 MBF	20
	501 to 1,000 MBF	25
	More than 1,000 MBF	40
Seasonal preference for sale timing?	Sumer	10
	Winter	20
	Spaced consistently throughout the year	70

Table 4. Gopof 1

Table 4. Buying preferences of JBLM timb 1

[1]MBF = 1,000 board feet

The effects on the economy of the ROI attributable to four forest products were investigated using existing economic studies and databases (Resource Dimensions 2012). Three of these products are offered in an existing marketplace: sawtimber, small-diameter roundwood and

firewood, and recreation. The fourth, forest *biomass*, has been previously offered in an emerging market, but discontinued when the market did not develop as expected.

The percentage of logging equipment operators employed solely to work on JBLM is 7.6% of industry employment and 0.001% of total employment in the ROI, a negligible economic impact. Although the JBLM timber-sale program provides average annual payments of $550,000 to Pierce and Thurston counties (Table 5), the 2011 share of total revenue for the ROI combined was 0.05%, a small economic contribution. JBLM firewood permit users pay much less per kilowatt-hour to burn firewood than they pay for electricity or gas from local utilities (17-25 times as expensive). However, the market share of heating value from fuelwood sold by the installation in 2011 was about 0.15% of the total kilowatt-hours sold by Tacoma Power, so the economic effect of firewood harvesting in the ROI is very small.

Table 5. Timber sale revenue and payments to counties, Joint Base-Lewis McChord, FY2011-FY2015.*

	Amount (1,000 $)					
Activity	2011	2012	2013	2014	2015	5-Year Average
Timber Sale Revenue	3,606	3,404	3,155	3,279	3,284	3,346
Expenses	2,231	1,888	1,654	1,932	2,163	1,974
Net Income	1,375	1,516	1,501	1,347	1,120	1,372
Payments to Counties	550	606	600	539	448	549
Payments to Forestry Reserve Account	825	910	901	808	672	823

*Source: US Army, Reimbursable Programs Tracking System.

The effect on the local economy (ROI) of trip expenditures associated with the five main types of forest-based recreation is negligible.

The number of people employed in 2009/2010 combined to haul forest biomass from the installation was 0.56 jobs, a tiny economic effect. As no biomass cogeneration facility currently exists at JBLM, and if one did, there would be no excess electricity sold directly to the public or to a utility, biomass energy production has and will continue to have no effect on the local economy (Resource Dimensions 2012).

Since almost all of the timber JBLM sells is FSC-certified, what is the impact of this timber on the market for certified wood in western Washington? During the past five years, JBLM has sold an average of 8.1 MMBF of commercial sawtimber, most of it from our certified land base. This pales compared with the total output of certified timber from state and private lands. Currently, 172,000 acres of WDNR lands are FSC-certified. Timber harvest on WDNR FSC-certified lands was 37 MMBF in 2015, or 10% of the total Westside harvest of 374 MMBF (Washington State Department of Natural Resources 2017). Based on these figures, JBLM provided 22% of FSC-certified wood to Westside mills, a not insignificant contribution.

A less environmentally stringent certification, the Sustainable Forestry Initiative (SFI) covers all 2.1 million acres of WDNR forest lands, plus 3.3 million acres of private forests (Washington Forest Protection Association 2017), about one-third of all private forestland. In western Washington, sawmill consumption from private forests in 2014 was roughly 67% of total consumption (3.45 MMBF) or 2.31 MMBF (Washington State Department of Natural Resources 2015). If one-third of this came from SFI-certified lands, then the total SFI contribution was about 77 million board feet. Thus, the total (FSC + SFI) certified wood market in western Washington is approximately 37 + 77 = 114 MMBF, with JBLM's share being only 7%.

FOREST RESOURCES

Military Use

Military use of JBLM's forests consists of both mounted (motorized vehicles) and dismounted (foot travel) training. Forests are valuable because they provide *vertical concealment* for troops and vehicles from airborne and satellite reconnaissance and protection from projectiles such as bullets. There is frequent use of the forested portions of the training areas by military units ranging from squads to battalions. The biggest challenge for training in forests is impediments to movement, such as thick brush, down logs, and slash piles from logging.

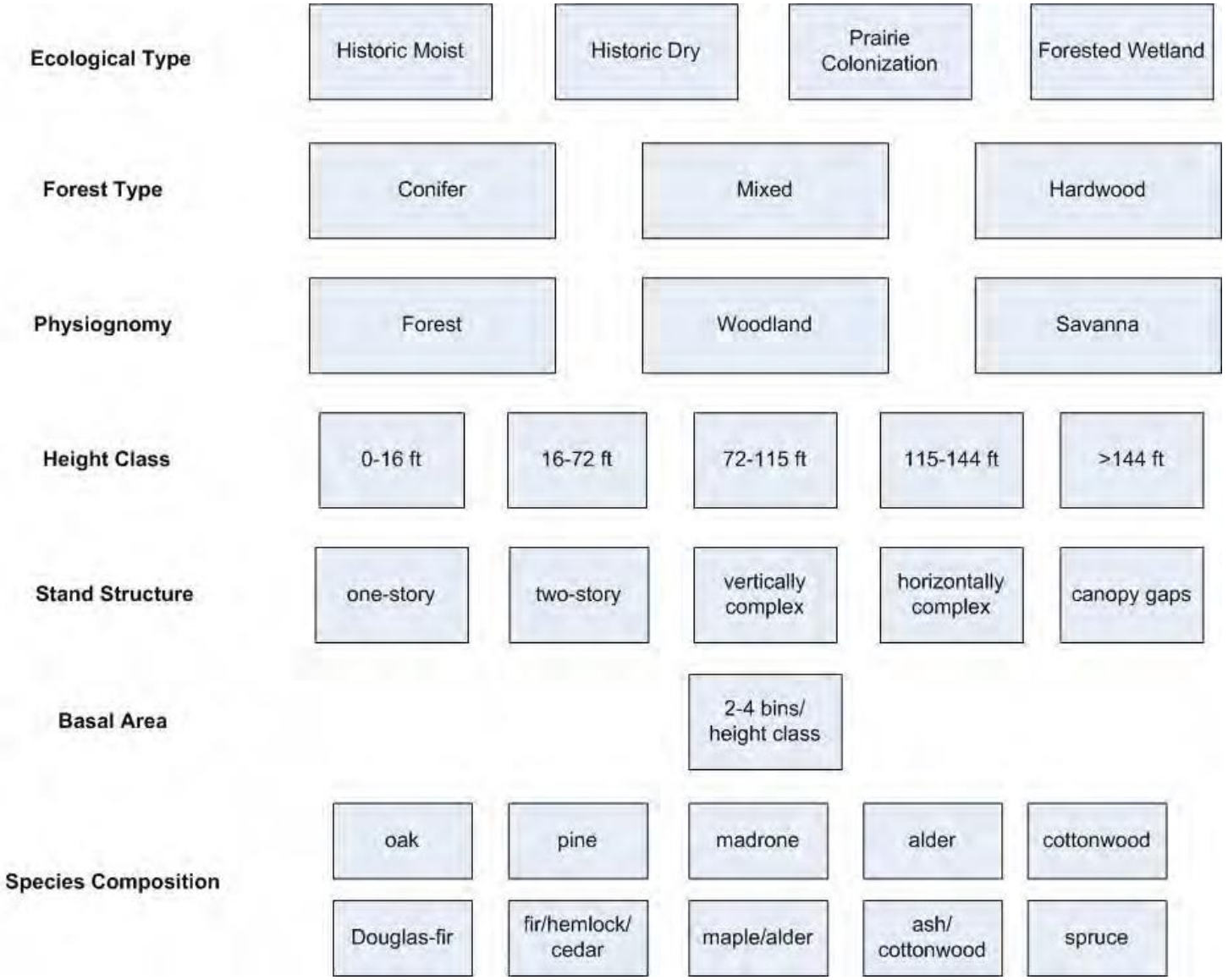
Forest-grassland edges have particular value as staging areas for troops and vehicles prior to assaulting targets out in the open.

Forest Stands

For management purposes, the forested landscape at JBLM is divided into *forest stands*. Fort Lewis's stands were initially mapped in the 1980s, using a combination of ecological and human (roads and land-use classifications) boundaries. As of the end of 2013, the Forestry Branch finished remapping the Fort Lewis portion of JBLM's forest stands, using only ecological boundaries, to facilitate ecosystem management and to fulfill an FSC requirement. This mapping was based on a hierarchy of stand classification criteria (Figure 9). Ecological type (historic moist, historic dry, prairie colonization), forest type (conifer, deciduous, mixed), and physiognomy (closed forest, woodland, savanna) are the same as in the JBLM vegetation classification, while species composition is equivalent to the Formation level (Table 3). Height class is based on the average canopy-top height. Stand structure is based on the number of distinct vegetation layers in the forest canopy, the degree of vertical and horizontal complexity of the canopy, and whether or not canopy gaps are present. One-story stands have a single layer of overstory trees of fairly uniform height, with few understory trees and a sparse to nearly continuous shrub layer. Two-story stands have two distinct canopy layers, an overstory and a more or less continuous understory of younger trees. Vertically complex stands have multiple canopy layers. Horizontally complex stands vary spatially in tree height and presence of various canopy layers. Canopy-gap stands are any of the previously described stand structures that also have multiple canopy gaps (less than one acre in size), formed naturally (e.g., fungal pathogen mortality, windthrow) or created deliberately (e.g., to promote conifer regeneration).

Plantations are a subset of one-story stands that were initiated by tree planting, usually following timber harvest. There are 235 such areas established since 2000, ranging in size from one to 80 acres. These areas receive varying amounts of treatment, including precommercial thinning,

Figure 9. Hierarchical forest stand classification for Joint Base Lewis-McChord.



brush control (generally within the first 15 years after tree planting), etc., until no further treatment is needed prior to commercial harvest.

The distribution of stand types, by various classification criteria, is shown in Table 6.

The current mapping of ecological types on JBLM is outdated, in part because it is based on older soil surveys than the new survey completed in 2012. Because the new survey includes several new complexes, each consisting of multiple soil series, the topographic and soil determinants of the component series must be worked out. This will be accomplished using plant communities that are indicators of the forest types (see Inventory and Monitoring).

Of the species composition categories, only oak- and pine-dominated stands are currently part of the ecological stands because they have been mapped directly on the ground. Neither aerial photography nor remote sensing can be used to map individual tree species occurrences.

Light detection and ranging (LiDAR) remote-sensing data from 2010 were a major part of the stands delineation. These data did not include McChord Airfield, so stands have not been designated there. However, new LiDAR data were collected in 2016, including McChord, so all of JBLM will be newly remapped for stand boundaries in 2017.

A total of 1,364 stands is currently delineated (Figure 10). JBLM is dominated by closed (greater than 60% canopy cover), conifer-dominated forests (Table 6). The majority of these stands are vertically or horizontally complex, and the most dominant ecological type is prairie colonization forest.

Each forest stand is also classified as *precommercial*, *commercial*, or *non-commercial*, depending on the potential for removal of forest products. Precommercial stands are composed of young trees that are too small to remove as a timber product. When these dense stands are thinned, the growth of the residual trees increases. Commercial stands are comprised of larger trees (average diameter typically 12 inches) that satisfy sawlog specifications and are harvested through competitively bid timber sales. These are the "bread and butter" of JBLM Forestry, providing most of our operating income. Non-commercial stands have too low a *basal area* or too many low-value species to be managed as commercial stands, or are set aside for conservation and other non-timber purposes.

Timber Sales

The Timber Sale Program of the Forestry Branch designates areas for commercial wood harvest, determines how much wood is available and the harvest method to be used, and marks trees to be cut. Actual sales are sold and administered by the USACE, which maintains an office on JBLM.

During the past five years, JBLM Forestry has sold 99 timber sales in the training areas, with an average annual harvest of 9.0 million board feet across 1,382 acres. Harvest types have included VDT (most sales), clearcut, and salvage (Table 7).

Variable-Density Thinning

The goal of VDT is for the post-harvest stand to be more heterogeneous than the pre-harvest stand (Figure 11). This is accomplished by marking trees across all commercial size classes (except the largest trees) in a stand. In some areas, clumps of trees are marked; in other areas, no trees are marked (i.e., a "skips and gaps" approach). In the rest of the stand, there is uneven

Table 6. Occurrence of various types of stands on Joint Base Lewis-McChord*.

Activity	Acres	Percent of Forest[1]
Ecological type		
prairie colonization	32,688	53
historic dry	9,462	15
historic moist	17,960	29
forested wetland	1,163	2
Forest type[1]		
conifer	41,523	68
mixed	17,849	29
deciduous	1,003	2
Physiognomic class[1]		
closed forest	55,805	92
woodland	2,608	4
savanna	1,603	3
Height class		
0-16 feet	332	1
16-72 feet	17,269	28
72-115 feet	21,816	36
115-144 feet	18,696	31
> 144 feet	1,904	3
Stand structure		
plantations	2,480	4
other single-story	5,199	9
two-story	2,496	4
vertically complex	39,554	65
horizontally complex	10,287	17
(canopy gaps)[2]	(5,103)	(8)

*Fort Lewis portion only.

[1]Total forest area (closed forest, woodland, savanna) = 60,686 acres (Fort Lewis only). Minor forest types are excluded, so the total acreages in each table category are less.

[2]Canopy gaps constitute a portion of each of the other four stand structures, but they occur only in closed forests.

Figure 10. Ecologically-based forest stands on Joint Base Lewis-McChord.

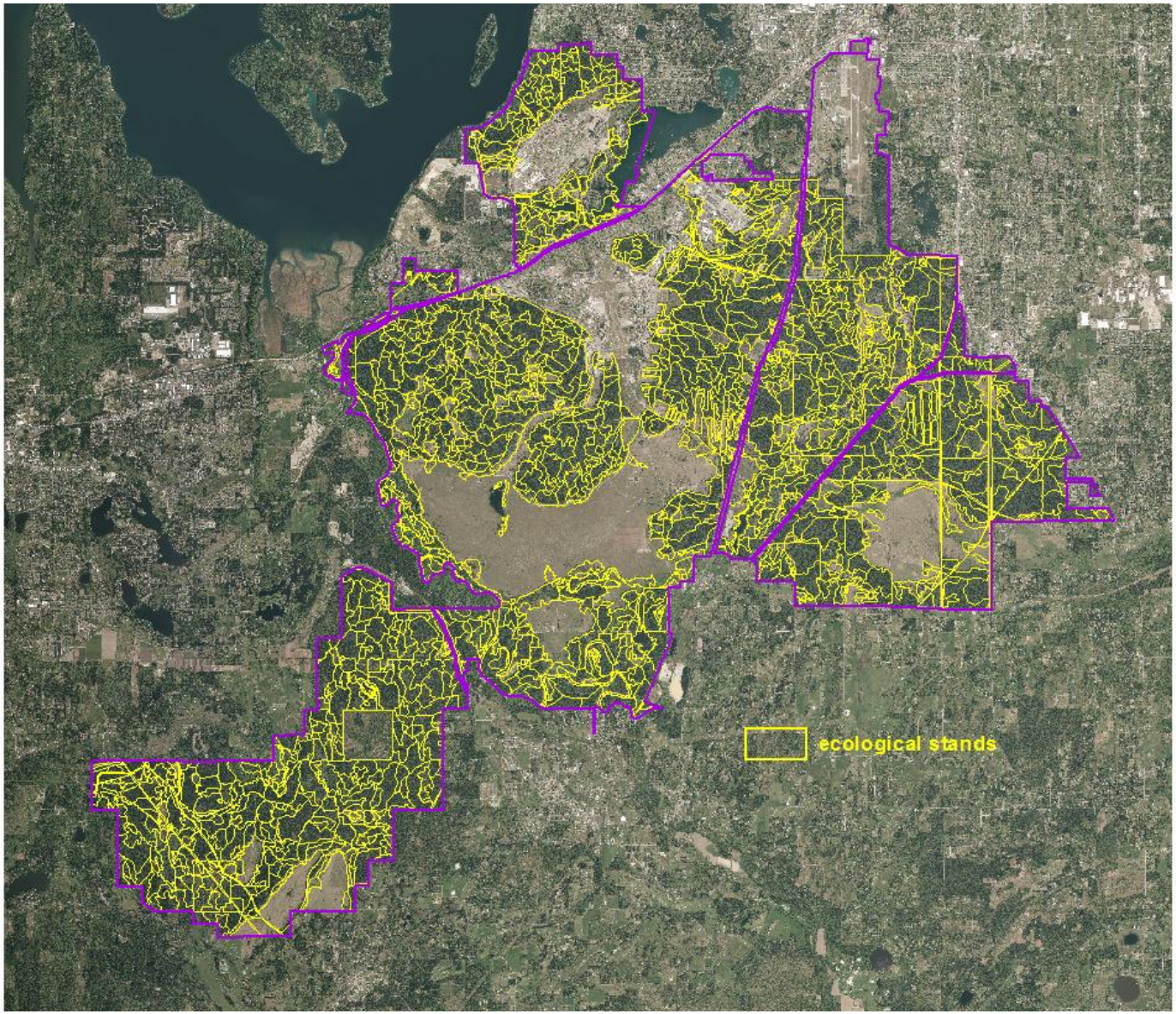


Table 7. Timber sales at Joint Base-Lewis McChord, 2011-2015.

Activity	2011	2012	2013	2014	2015	5-Year Average
Active Timber Sales (number)	18	16	13	9	9	13
Harvest (acres)	1,764	2,076	1,294	688	1,090	1,382
variable-density thinning	1,584	1,419	1,120	611	1,090	1,165
clearcut	180	7	124	77	0	78
salvage	0	650	50	0	0	140
Volume (MMBF*)	11.74	9.62	8.55	7.13	7.80	8.97
commercial sawtimber	11.15	8.46	7.27	5.93	7.62	8.09
commercial log decks	0.22	0.83	1.01	1.05	0.12	0.65
firewood	0.37	0.33	0.27	0.15	0.06	0.24

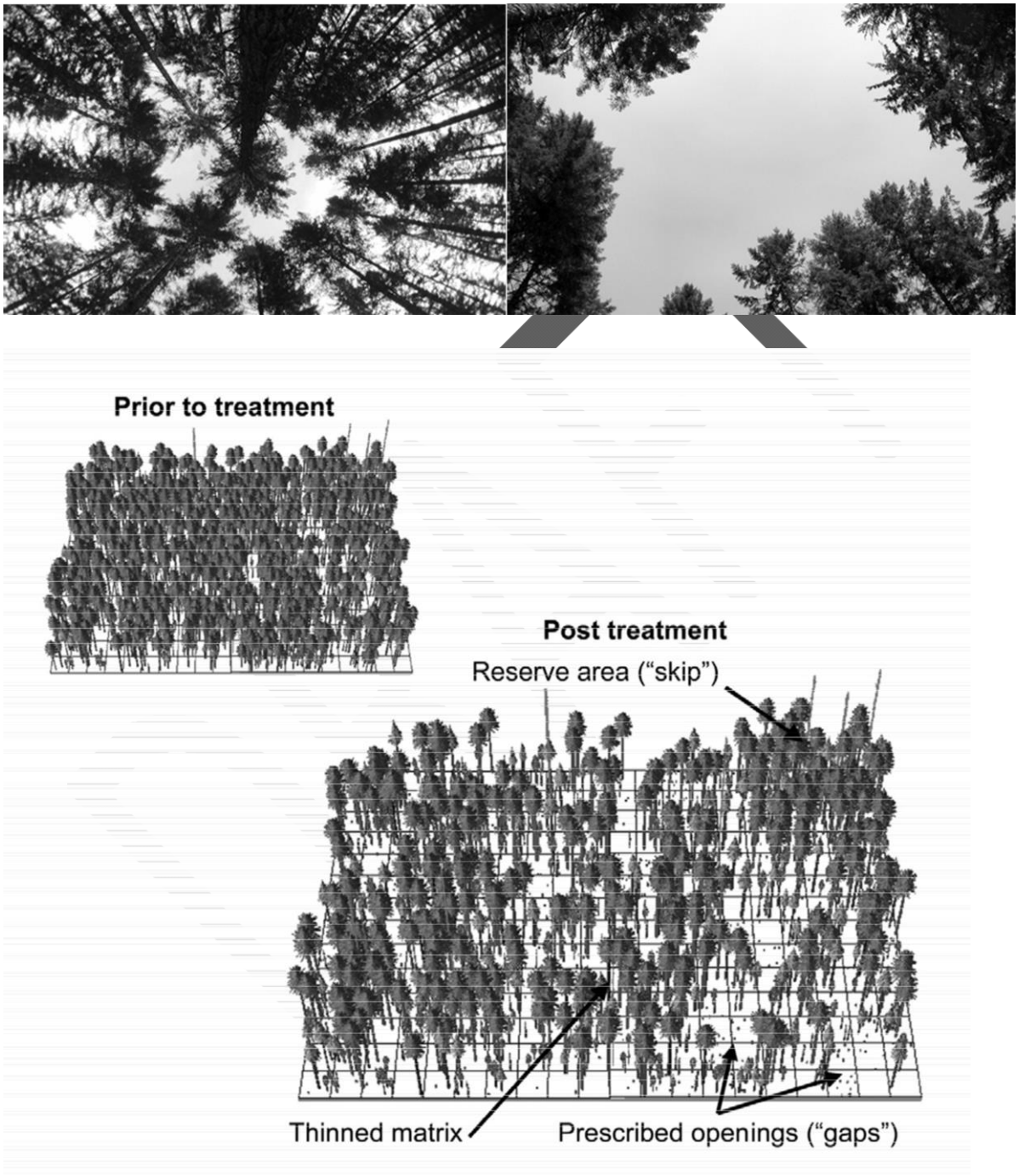
*million board feet

spacing between marked trees. In young, dense commercial stands, small (≤ 0.5 acre) openings may be created to facilitate regeneration. Non-commercial species are not normally marked for removal. In contrast, traditional thinning, practiced by JBLM Forestry prior to about 1990, has as its goal a more homogeneous post-harvest stand than the pre-harvest stand. In this case, tree marking is relatively constant in density across the stand and most intermediate and suppressed trees, and stems of non-commercial species, are marked for removal.

There is substantial documentation of the benefits of VDT. Roberts and Harrington (2008) found that individual trees in the thinned matrix of stands that have received VDT show increased growth compared to trees in unthinned patches, particularly in previously unthinned stands. Trees next to canopy gaps and skid trails also show increased growth. Long-term, landscape-level experiments have demonstrated that VDT and similar types of silviculture (e.g., *variable-retention* harvest) enhance within-stand structural diversity, which is particularly important for meeting wildlife needs (Carey et al. 1999, Peterson and Maguire 2005, Wilson and Puettmann 2007).

JBLM was the study site for the 20-year-long Forest Ecosystem Study (FES; Carey et al. 1999), which experimentally examined VDT as a tool to stimulate development of late-successional attributes in managed forests that are favored by the northern spotted owl and its prey base. In this study, VDT simulated natural disturbance processes in a mosaic of treatments. The study sites were even-aged Douglas-fir stands in the RTA. Half had received two traditional thinnings; the other half had not been thinned and retained legacy (Carey et al. 1999). Multiple structural and functional forest attributes were measured before and after treatments, with emphasis placed on the "keystone complex" of interactions between spotted owls, northern flying squirrels, *ectomycorrhizae* (fungi that are a favorite flying squirrel food), and Douglas-fir (Carey 2003, Duncan 2004).

Figure 11. Variable-density thinning (VDT) silviculture. Top left photo shows an unthinned area ("reserve area" or "skip"), the photo next to it a canopy gap ("prescribed opening"). The bottom diagram illustrates an unthinned stand and how it might look after a couple of rounds of VDT, with at least one of the rounds includng deliberate creation of canopy gaps. From Mazza (2009).



All stands had similar soil flora, heavily dominated by fungal *mycelia* and fungi-eating nematodes. However, thinned stands had reduced dominance of macroscopic fungal mats. Thinning produced stands with a rich understory dominated by clonal native species, with numerous exotics present, whereas unthinned stands had *depauperate* understories and low abundances of small mammals. Thinning mosaics increased diversity and abundance of native plant species, but only ephemerally increased exotics. Neither the thinned nor unthinned stands appeared to be on a trajectory to develop the complexity and diversity of old-growth forests. In addition, despite attempts to improve flying squirrel habitat (e.g., artificial cavities, nest boxes), squirrel populations declined over the course of the study. However, the possible influence of increasing numbers of barred owls, which outcompete spotted owls for habitat, was not evaluated. This research showed that the creation of owl habitat is a long-term process that may require periodic management intervention over a timescale of many decades.

Other Harvest Methods

Ten clearcuts, totaling 388 acres, occurred on JBLM in the last five years (Table 7). Four sales (236 acres) were to accommodate military training needs, three sales (88 acres) to accommodate construction, two sales (24 acres) to benefit ESA-listed wildlife, and one sale (40 acres) to convert a decadent alder stand to a mixed stand.

Following major windstorms or icestorms, salvage sales occur to remove downed trees across and within 100 feet either side of roads. The most recent sale of 700 acres followed a devastating snow/ice/wind storm in January 2012 (Table 7).

Some stands in historic moist forests are dominated by alder. Starting at about age 40, this species begins to senesce. In such cases, conversion to a mixed (conifer/hardwood) stand is desirable, unless laminated root rot is present. In addition, alder is a high-value forest product. These stands may be clearcut and planted to conifer species. One sale of this type has occurred, in 2015, within the Spotted Owl Focus Area, where mature conifer-dominated stands are desired.

Forest-Grassland Edges

The boundaries between grassland and forest are abundant at JBLM. Often, as a result of past and current land use, these edges are abrupt. In other cases, they may be more diffuse, or there may be woodland between the grassland and closed forest. Where timber sales extend to the edges of grasslands, the Forestry Branch consults with JBLM Fish & Wildlife on removal of extra conifers that are overtopping oak, and to create savanna-like conditions with shadier, moister microhabitats that may benefit Taylor's checkerspot.

Logging Slash

Logging slash is debris left over from logging: tree tops, stumps, branches, unmerchantable portions of trunks, etc. Excessive slash is an impediment to unmounted maneuver. However, some slash must be left on site to decay and provide nutrients and organic matter to the soil, and to provide habitat for forest floor animals.

Logging slash can be locally excessive following timber harvest, which can inhibit training or pose a fire hazard. Under most circumstances, air quality concerns prevent disposal of slash by burning. To reduce slash as an impediment to training, timber sale contracts currently require the following:

- After felling, trees are *yarded* to logging landings, where non-merchantable branches and tops are removed.
- Residual slash in the woods is run over by logging machinery to reduce average depth to no more than 12 inches.
- All slash remaining at the landings must be removed by the logger. Alternatively, slash at the landing may be used to armor skid trails to avoid rutting and minimize compaction.

Road Construction and Maintenance

New road construction is rare on JBLM because an extensive road system is already in place, created mostly to fulfill military training needs and, in the past, the extensive timber harvest that occurred. Road maintenance consists of grading, adding rock to rutted areas, cutting back brush encroaching on roads, and controlling noxious weeds. JBLM Public Works, Roads & Grounds, handles maintenance of paved roads and designated major gravel roads. Forestry handles maintenance of roads that act as firebreaks, particularly in plantations and impact areas. Maintenance of roads for hauling wood in timber sales is provided by loggers as part of their timber-sale contracts.

Stand Development

Reforestation

The Army has a mandate to reforest cutover areas unless a decision has been made to change the land use to non-forest. The Stand Development Program in the Forestry Branch oversees re-establishment of forest cover after timber harvest, starting with *site preparation* and *tree planting* (Table 8). In some cases, mechanical (i.e., using heavy equipment) site preparation is used to remove thick native and non-native brush that competes with planted trees, occasionally followed by *scarification* to loosen compacted soil from logging equipment. However, in the long term, the use of herbicides to control brush is more effective at increasing planted tree growth, and avoids ground disturbance. Tree planting or *artificial regeneration* utilizes tree seedlings grown in tree nurseries. Most of these seedlings are grown from seed collected from JBLM or from adjacent *seed zones*. Following some timber harvests, reforestation relies on *advance (natural) regeneration*: tree seedlings and saplings already present in the understory prior to timber harvest. In western Washington, *natural seeding* is not dependable due to brush competition. Although most artificial regeneration occurs in clearcuts, *underplanting* (planting

Table 8. Stand development at Joint Base Lewis-McChord, fiscal years 2011-2015.

	Acres					
Activity	2011	2012	2013	2014	2015	5-Year Average
Site preparation	82	140	91	0	50	63
Tree planting	121	140	91	0	0	351
Precommercial thinning	0	0	0	0	436	87
Herbicides[1]	0	0	258	156	66	n/a

[1]Broadcast spraying only. Spot spraying is conducted by JBLM Fish & Wildlife at hundreds of locations.

underneath existing forest overstory) may occur where a partial harvest, such as VDT, has reduced the overstory to a basal area less than 120 square feet per acre. In these areas, canopy cover is typically 50% or less, and enough light reaches the ground for shade-tolerant tree species to grow. In recent years, the only underplanting on JBLM was several hundred acres of conifer stands in 2004.

The current standard for fully stocked regeneration areas is 300 *free-to-grow* trees (i.e., with good vigor and free of competition) per acre in clearcuts, and between 100 and 200 trees per acre, depending on species planted and amount of residual overstory, when underplanting. Because of mortality from competition, deer browsing, and disease, initial tree plantings are typically 600 trees per acre in clearcuts.

Timber Stand Improvement

If young stands become overstocked (more than 350 trees per acre), competition between trees results in high mortality and substantially reduced growth; such stands often receive *precommercial thinning* (PCT; Table 8). Occasionally, stocking rates exceeding 600 trees per acre. These stagnant, "dog-haired" stands can't be resurrected by PCT, but must be clearcut and replanted. Once stands have large enough trees (typically an average dbh of 12 inches or greater), they become available for commercial timber harvest.

Fire Management

The Wildland Fire Management Program of JBLM Forestry is responsible for prevention and management of *wildfires*, almost all of which are started by military training (e.g., exploding shells, *pyrotechnics, tracers*). Forestry is assisted by the JBLM Fire Department and JBLM Fish & Wildlife. JBLM also has mutual aid agreements with WDNR and adjacent fire districts for suppression of wildfires.

Wildfire

Data on JBLM wildfires in recent years are incomplete (Table 9). It is known that most of the acreage is in the Artillery Impact Area, where fires are allowed to burn out to the perimeter roads because the risk of unexploded ordnance is too high to fight these fires directly. Annual wildfire occurrence is affected by several factors: (a) Weather, e.g., the length of the summer drought, whether or not the drought is interrupted by significant rainfall, and the daily pattern of temperature, humidity, and cloud cover. Drier, warmer weather promotes drying of fuels. (b) Fuel loads. Different size classes of vegetation debris, from grasses, twigs, and leaves (1-hour

Table 9. Prescribed burns and wildfires at Joint Base Lewis-McChord, fiscal years 2011-2015.

	Number/ Acres					
Activity	2011	2012	2013	2014	2015	5-Year Average
Prescribed burns	38/1,779	68/2,574	51/918	62/2,320	74/1,725	57/1,860
Wildfires	26/3,379	no data	14/2,684[1]	9/1,649[1]	6/142[1]	n/a

[1]Incomplete data

fuels) to snags and logs (1,000-hour fuels), occur patchily across JBLM's forested landscape. Each size class becomes available as fuel when its moisture content falls below a threshold value. (c) The number of troops assigned to JBLM and not deployed elsewhere. More troops → more training → more opportunities for accidental ignition.

Wildfires on JBLM are managed under four different strategies: monitor, contain, control, and suppress. Fires being monitored have no action taken. These occur for the most part in the Artillery Impact Area. Outside of this area, once a fire is determined likely to continue to burn, a containment area is defined, using roads and adjacent, recently-burned areas as boundaries. If a fire stays within the containment area no further action is needed. If a fire threatens or crosses the containment lines, control actions are taken, such as *backfires* or minimum impact methods. *Suppression* (actively control and *mop up*) is often used for wildfires in forested areas because the abundance of fuel can help such fires spread rapidly. Suppression is also the only option in the North and Central Impact Areas because these are used daily for military firing ranges, and training is on hold until the fires are controlled. These fires may smolder for a long time because lack of access limits the ability to do mop up. On grasslands, contain and control are usually the best strategies.

Prescribed Fire

Prescribed fires (also called controlled burns) on JBLM are used primarily to control Scotch broom across large grassland areas, which (a) opens them up for training, (b) reduces fire risk by lowering fuel loads, and (c) helps maintain native grasslands. In JBLM's forests, they are one of the tools of ecological restoration, especially in oak and pine stands.

These fires are carried out only when fuel loads and fuel moisture are within acceptable burn plan *prescriptions* and there are no burn bans due to high fire danger or poor air quality during temperature inversions. Fire danger bans are imposed by the Wildland Fire Manager on JBLM and air quality bans by the Puget Sound Clean Air Agency. Exceptions to the latter are sometimes made for ecological purposes.

For both wildfire suppression and setting of controlled burns, important considerations are ensuring that fires do not get too large, shut down training for long periods of time, smoke out adjacent communities, or move off of DoD property.

Ecology

The Ecology Program in JBLM Forestry is responsible for implementation of the Forest Plan in an ecologically sound manner, *ecological restoration*, research, designation of conservation reserves, and monitoring. Plan implementation has two components: (a) annual reviews and periodic revisions of the Plan, and (b) review of proposed individual forest management projects for conformance to the Plan.

Ecological Restoration

Ecological restoration is conducted in unique forest ecosystems on JBLM, primarily oak and pine woodlands and savannas (Table 10). The purpose is to move these systems back towards their putative pre-European condition, restore natural processes that are absent (e.g., fire), and improve habitat for rare species that occur only in these ecosystems (Foster 1997). Restoration actions are carried out cooperatively with JBLM Fish & Wildlife.

Table 10. Ecological restoration in forests at Joint Base Lewis-McChord, fiscal years 2011-2015.

	2011	2012	2013	2014	2015	5-Year Average
Acres	220	76	150	0	0	59

Research

JBLM Forestry has supported forest ecology and management research for more than 20 years (Table 11). The objective is to fill in information gaps in our knowledge of the structure and function of JBLM forests, or to design better ways of managing various forest types. Focal areas for research in recent years have included designing an appropriate silviculture for prairie colonization forests, controlling native forest understory brush, management of Oregon white oak, and control of Scotch broom in forest plantations.

Table 11. Forestry-funded research at Joint Base Lewis-McChord, 1992-2015.

Project	Conducted by	Purpose
Forest Ecosystem Study	US Forest Service, Pacific Northwest Research Station	Experimental manipulation of young Douglas-fir stands to create suitable habitat for northern spotted owl prey
Oak restoration	US Forest Service, Pacific Northwest Research Station	Thinning release of Oregon white oak; fire effects on oak
Conifer regeneration	US Forest Service, Pacific Northwest Research Station	Light, water, and vegetation competition effects on conifer regeneration
Gap study	US Forest Service, Pacific Northwest Research Station	Forest canopy gap size effects on conifer regeneration
Scotch broom	University of California at Santa Cruz, Northern Arizona University	Control methods and underlying mechanisms of Scotch broom control in forest plantations
LiDar mapping of forest stands	Oak Ridge Institute for Science & Education	Use light detection and ranging remote-sensing to map JBLM's forest stands
LiDar mapping of spotted owl habitat	Colorado State University	Use LiDAR to map northern spotted owl nesting/roosting/foraging habitat

Additional topics included:

- Ecological forest stands
- Stand exam database
- Timber sales database
- Douglas-fir regeneration vigor

- JBLM vegetation mapping
- JBLM site index and volume equations
- Remote sensing of vegetation
- Ecological stand boundaries
- Northern spotted owl habitat mapping

Most of this research has been conducted by the Pacific Northwest Research Station of the US Forest Service (US Forest Service 2016), some by faculty members at academic institutions, some by participants in the Oak Ridge Institute for Science and Education (US Department of Energy 2016), and some by other contractors working for the JBLM garrison. In recent years, much research expertise has been obtained through Cooperative Ecosystems Study Units (CESU Network 2016).

Conservation Reserves

To maintain FSC certification, JBLM Forestry has designated High Conservation Value Forests (HCVFs) based on such factors as rarity or uniqueness of the vegetation, old-growth characteristics, susceptibility to erosion or flooding, etc. Forestry has also designated Representative Sample Areas (RSAs), primarily reference stands that remain unmanaged for comparison with managed stands (Table 12, Figure 12). Reserves have limited management (e.g., ecological restoration) or no management. The reserves are Forestry designations only; they do not have the same level of protection as Controlled Use Areas designated by Range Support.

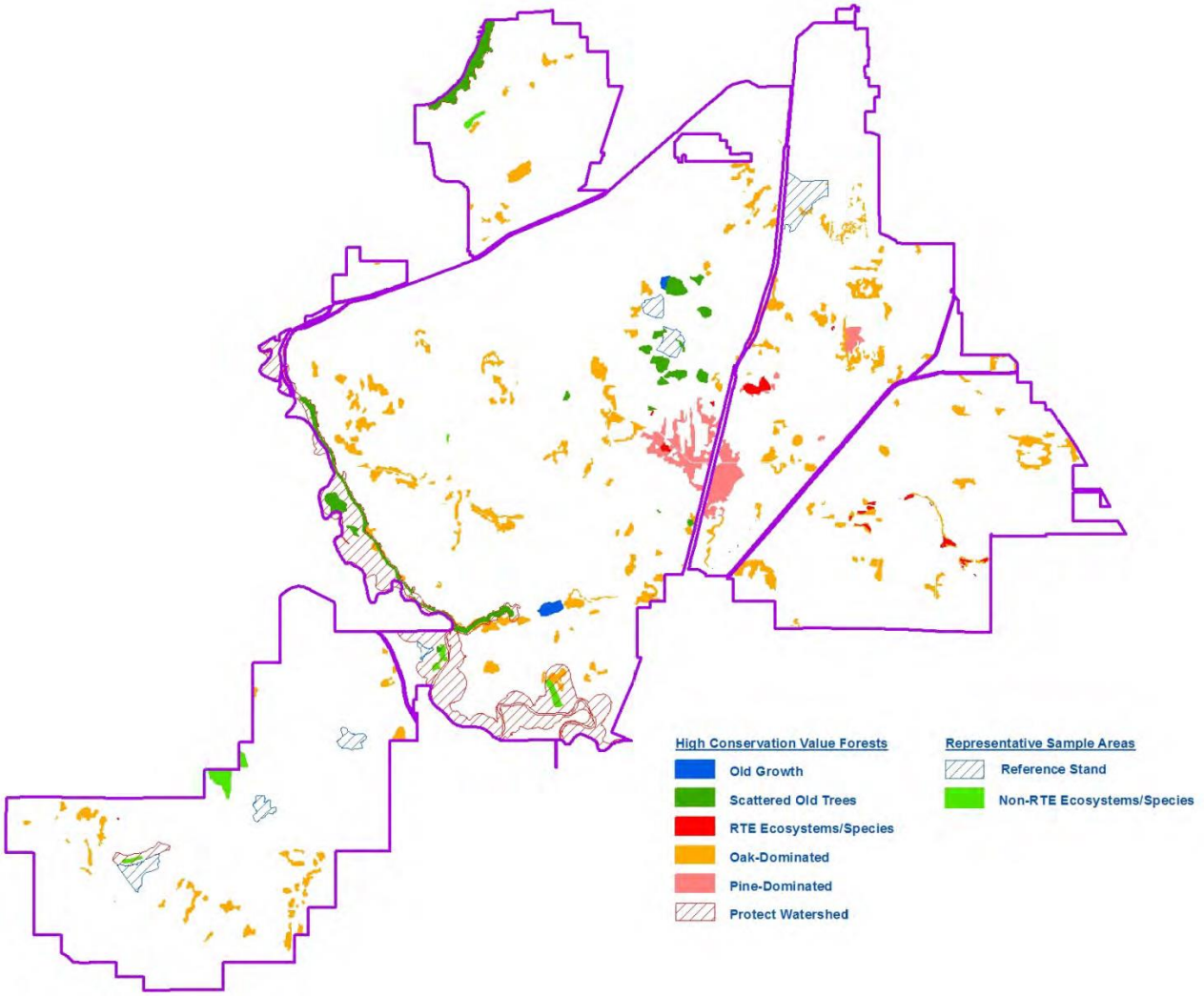
Table 12. High Conservation Value Forests (HCVFs) and Representative Sample Areas (RSAs) on Joint Base Lewis-McChord.

Type of HCVF or RSA	Acres	Management Restrictions
Old Growth	75	No management
Scattered Large Trees	865	No management
Oak-Dominated	3,640	Timber harvest (with safeguards) and ecological restoration allowed
Pine-Dominated	856	Timber harvest (with safeguards) and ecological restoration allowed
RTE Ecosystems/Species	141	No commercial timber harvest; ecological restoration allowed
Watershed Protection	3,178	No commercial timber harvest; ecological restoration allowed
Total HCVF*	7,953	
Reference Stands	863	No management
Non- RTE Ecosystems/Species	268	No commercial timber harvest; ecological restoration allowed
Total RSA	1,131	
Total HCVF + RSA*	8,806	

*Accounting for spatial overlap between designations.

Note: Wildfire control is permitted in all areas.

Figure 12. High Conservation Value Forests and Representative Sample Areas on Joint Base Lewis-McChord.



Disturbance

Various kinds of human and natural disturbance are constantly reshaping the structure and function of JBLM's forests.

Human Activities

The number one disturbance, in terms of acres affected and impact on forest structure, is commercial timber harvest. For example, during the past five years, a total of 6,910 acres of JBLM's forests received commercial harvest. Of these acres, 78 acres were clearcuts.

Ground-based logging systems are the primary harvesting method on JBLM (greater than 95% of all sales). Ground-based harvesting machinery includes wheeled and tracked equipment, such as *skidders*, *loaders*, *forwarders*, *feller-bunchers*, and bulldozers. This equipment has the potential to cause soil erosion, particularly on wet soils or steep slopes, or compaction, although JBLM's generally very rocky soils are highly resistant to compaction.

Another human disturbance is construction of buildings, ranges, and roads, which is episodic in nature but generally destroys all forest on site. Military training occurs year-round, but tends to be spread out with localized impacts, primarily loss of ground cover, in forests.

Fire, Windstorms, and Icestorms

Wildfires are considered human disturbances on JBLM because all are initiated by troop activity. The current climate of the Puget Sound lowlands rarely generates thunderstorms, and when lightning activity occurs, it is always accompanied by rain. Thus, there are no natural sources of ignition. Prescribed burning affects about 1,900 acres of JBLM annually, mostly in grasslands, but during the past five years, ≈ 500 acres of prescribed burns have affected forest resources, mostly in oak and pine woodlands and savannas. Winter windstorms blow down individual trees and sometimes groups of trees, but otherwise do not cause much damage. However, two icestorms, in December 1996 and January 2012, caused widespread forest damage at JBLM, including uprooted trees, trees with part or all of their crowns snapped off, and large quantities of fallen branches. Damage was particularly severe in hardwood (maple, alder) stands and young, dense conifer stands, and in suppressed trees in otherwise relatively undamaged stands. The most vulnerable trees had large *height:diameter ratios*, i.e., short narrow crowns at the top of long stems, which, when they accumulated ice, made them top-heavy. There was also substantial branch loss from oaks.

Floods

Although the Nisqually River's flows are controlled by Alder Dam, well upstream of JBLM, the River still floods (water height 10 feet or more at McKenna, WA, gauge) at irregular intervals. Twenty flood events have occurred since 1951 (National Weather Service 2016). The largest flood, in winter 1996, rose to 17 feet and caused considerable rearrangement (cut-off *meanders*, disappearance of existing and appearance of new sandbars, undermining of steep bluffs immediately adjacent to the river) of the *floodplain* topography of the Nisqually where it crosses JBLM. A new meander created by the 1996 flood was cut off by a flood in winter 2009 (Google Earth aerial photography).

Floods of this magnitude can uproot trees and even carry away entire stands of trees. Newly created sandbars are quickly colonized by willows (*Salix* species) and black cottonwood (*Populus grandidentata*). In the continued absence of major flooding, red alder and, eventually, bigleaf maple, grand fir, and Douglas-fir appear and succession proceeds towards conifer or mixed wetland forest.

Fungal Diseases

The most problematic tree pathogen on JBLM is laminated root rot (LRR; *Phellinus sulpharescens*), which is known to infect Douglas-fir throughout its geographic range. Western hemlock and grand fir are also susceptible. Western redcedar is immune, but can succumb to the related species, *Phellinus weirii*. However, most *P. weirii* occurrences are east of the Cascade Mountains, and none has been documented in the Puget Lowland (Washington State Academy of Sciences 2013). Pine species are resistant. Hardwoods are immune.

LRR spreads via root-to-root contact between infected and uninfected trees, causing wood decay in roots and the bases of tree trunks and, eventually, tree mortality. In infected trees, the first symptom is reduced growth, followed by visual symptoms (e.g., foliage loss) in the tree crown, and finally, tree death. Due to the decayed roots, still-living and recently-dead trees are highly susceptible to windthrow (Figure 13).

LRR begins as infection centers which spread outwards at the rate of one to several feet per year, so that some centers may become many acres in size. The dead and dying trees in these centers create forest openings where canopy cover is reduced, multiple snags and logs are present, and tall shrubs (native or Scotch broom) grow to form thickets (Figure 13).
LRR is an *endemic* disease, meaning that it is continuously present in infected stands, regardless of tree age. Even if all of the dead and dying trees in an LRR-infected stand are removed, the fungus persists in leftover stumps and roots for as long as 50 years. If new trees of susceptible species establish in such stands, they will become infected through contact with fungus-containing dead wood, perpetuating the disease cycle.

At JBLM, LRR was recently surveyed by visiting 736 potential infection centers comprised of clusters of three or more recently dead trees, as observed on aerial photographs (Foster 2010). Added to this were openings created as part of timber sales that removed trees from LRR-infected areas. LRR is most widespread in historic dry conifer forests and somewhat less so in historic moist conifer forests. It was historically absent from prairie colonization forests, but its prevalence in these forests is steadily increasing (Figure 14). Some spatial patterns are evident: (a) The highest concentration of LRR is in Training Area 4. (b) LRR is apparently absent or almost absent in:

- Training Area 17.
- The central and northern portions of Training Area 13.
- The northern portion of Training Area 10.
- All of Training Areas 2, 8, 10, 11, 14, A-West, and A-East.
- The Ammunition Storage Point, McChord Airfield, and North Impact Area.

Based on this analysis, the total area infected by LRR in 2010 was estimated at 1,920 acres.

Figure 13. Canopy gap created by laminated root rot (above) and windthrown trees infected with root rot (below) at Joint Base Lewis-McChord.

There are several caveats for these results. First, not all potential infection centers were visited, in particular in the impact areas. Second, the survey protocol was for rapid assessment; thus, presence of LRR could have been missed in some potential infection centers. Third, definitive evidence of LRR, using three criteria, was necessary to conclude it was present; in centers that have been infected for a long time, finding all three criteria was impossible. Finally, ground reconnaissance and the biology of LRR suggest that much larger areas surrounding and between actual infection centers are infected but not yet showing symptoms; these would not show up in the survey. It is likely, therefore, that total infected area is two or three times the visibly affected area, or as much as 6,000 acres.

Prior to about 2000, LRR was perceived by JBLM Forestry to be a low-level, natural source of gap creation in our conifer forests that contributed to habitat heterogeneity, and only a handful of stands were considered to be problem stands where LRR mortality had a large influence on stand

structure. However, it gradually became apparent from ground observations that the extent and severity of LRR was increasing on JBLM. Initially, Forestry experimented with heavy tree removal (i.e., small clearcuts plus buffers) in infection centers, followed by stump removal. However, a literature review and consultation with forest pathologists indicated a consensus scientific opinion that it isn't possible to eliminate LRR from forest stands, and that continued LRR presence means future mortality of susceptible tree species (Foster 2010). Thinning is not an effective strategy because the apparently healthy leave trees are usually already infected and, in Douglas-fir at least, there is no relationship between tree vigor and susceptibility to infection. If infection centers are clearcut, replanted trees of susceptible species will become infected, regardless of whether tree stump removal occurs following logging. Currently, Forestry removes diseased trees in infection centers, but leaves healthy-appearing trees, and there is no stump removal.

The only other fungal species causing significant tree mortality at JBLM is shoestring rot (*Armillaria solidipes*). It infects roots and *butts*, and can cause mortality of, Douglas-fir, western hemlock, and grand fir. Western redcedar is resistant. Mostly young trees are killed, while mature trees may tolerate infection for many years before succumbing. In western Washington, trees usually die individually, i.e., infection centers do not form. Unlike LRR, direct root-to-root contact is not required for infection to spread.

Individual tree deaths, here and there, are attributable to:

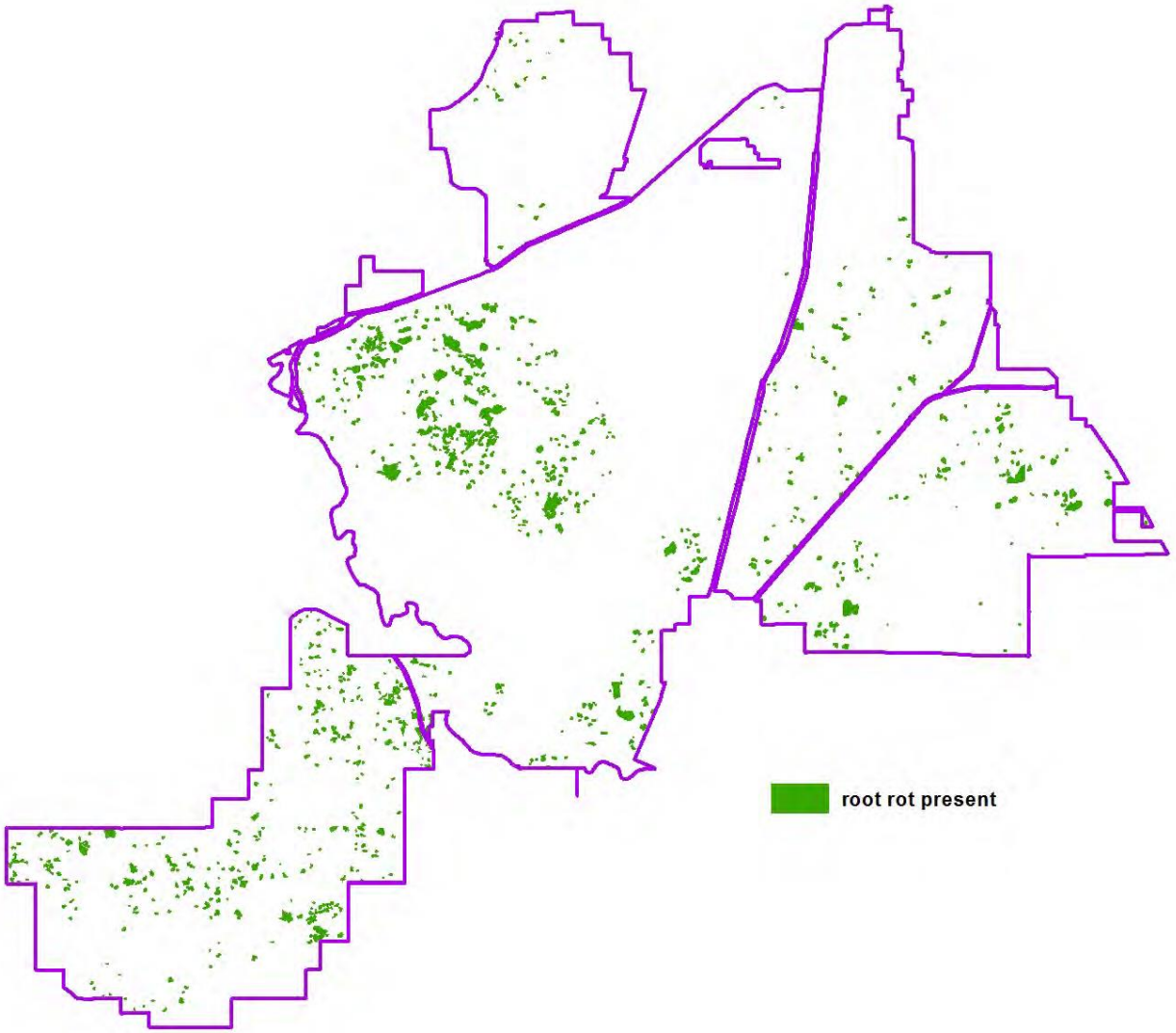
- Cubical butt rot/velvet-top fungus (*Phaeolus schweinitzii)* causes root and butt decay in Douglas-fir, western hemlock, pine species, grand fir, and Sitka spruce.
- Brown top rot *(Fomitopsis cajanderi)* causes stem decay, primarily in Douglas-fir, but also in other conifers. Decay appears 50 feet and higher up the stem.
- Red ring rot/white speck *(Phellinus pini)* causes stem decay in Douglas-fir, western hemlock, pine species, grand fir, and Sitka spruce.
- Red belt fungus/red crumbly rot (*Fomitopsis pinicola*) is the most common decay fungus of stumps, snags, logs, and slash of both conifers and hardwoods. It rarely infects living trees.
- Quinine conk (*Laricifomes officinalis*) causes heart rot of tree trunks and tops in Douglas-fir, western hemlock, pine species, grand fir, and Sitka spruce.
- Hardwood trunk rot (*Phellinus igniarius*) causes severe heart rot in hardwood species.

Decay by these fungi generally takes years before tree death occurs, so the primary effect is *defect* (pockets of dead, decaying wood) in living trees. Defect reduces the volume of commercial timber in forest stands, but it also results in cavities and other physical deformities that have high wildlife value.

During the late 1990s, there was an outbreak of the fungus *Fusicoccum arbuti* which caused significant mortality of madrone in Puget Sound, including at JBLM (Adams and Hamilton 1999, Elliott et al. 2002, Farr et al. 2005).

No insect outbreaks have occurred in JBLM's forests in recent memory. Tree defect attributable to insects is uncommon, consisting mostly of carpenter ant nests in conifers. The pine coneworm (*Dioryctria auranticella*), which feeds on ponderosa pine cones, is present on JBLM (Kohler 2012) and in some years causes obvious deformity and early abortion of cones. California five-spined ips (*Ips pini*), a bark beetle which can seriously damage young pines and cause tip

Figure 14. Geographic extent of laminated root rot infection centers on Joint Base Lewis-McChord.



mortality of mature pines, was detected on JBLM in 2012 in insect traps (Kohler 2012), but no tree damage attributable to this species has been verified.

No insect outbreaks have occurred in JBLM's forests in recent memory. Tree defect attributable to insects is uncommon, consisting mostly of carpenter ant nests in conifers. The pine coneworm (*Dioryctria auranticella*), which feeds on ponderosa pine cones, is present on JBLM (Kohler

Inventory and Monitoring

Forest *inventory* measures the current status of the forest. Forest *monitoring* tracks how this status changes over time. At JBLM, there are several types of inventory and monitoring, accomplished in-house or by contract. Each of these projects must have appropriate *experimental design* and field protocols to assure accurate and repeatable measurements. Once collected, the data must receive quality assurance, then be analyzed to produce timber volume and other forest metrics.

Existing Forest

Until 2004, JBLM Forestry maintained a regular grid of Continuous Forest Inventory (CFI) plots. These 1/5th-acre plots were permanent, i.e., were marked so that they could be relocated and remeasured at specified intervals. At each measurement, inventory (commercial wood volume "on the ground") was calculated using standard forest *mensuration* techniques. Because every tree was tagged with a number, repeat measurements over time allowed calculation of *net growth* and *mortality* at regular intervals.

The CFI plots were first established across the Fort Lewis portion of JBLM in 1963 and last re-measured in 2005. As discussed in Public Forestry Foundation (1995), three different methods have been used to calculate commercial wood volume over the years since the CFI was begun. The number of plots and the number of acres used for calculating volumes have also changed. The number of CFI plots (107 to 125, depending on the year) is small, and since the plots are systematically spaced across the installation, they are not necessarily representative of the mix of forest types on JBLM. In addition, there are no CFI plots on McChord, although the *standing stock* there is probably less than 5% of the total standing stock of JBLM. Furthermore, the 2005 data have never been analyzed, and we can't use the computer programs originally used to calculate volumes because they were written for DOS, and are no longer runnable in the Microsoft Windows environment. Finally, a recent examination of the raw CFI data found numerous errors. Taken together, these caveats mean that the CFI data must be interpreted with caution, and that they are currently good only through 1999.

The Intensive Stand Inventory (ISI) was designed to track the progress of JBLM's forests towards having the attributes of northern spotted owl habitat. Specific targets were based on Bottorff (1994). The ISI design uses randomly-chosen, *replicate* stands in each of the major forest types. Within each stand, data are collected from a regularly-spaced array of plots. These same stands are remeasured periodically to follow change over time. Because measurements are intensive, it takes five years to remeasure all stands. Initial ISI measurements occurred in 1999-2003, and were repeated in 2004-2008. The ISI was specifically designed to have adequate statistical power to detect biologically significant trends for each attribute measured (Foster 2001).

The CFI (and, to a large extent, ISI) were replaced by a comprehensive *stand exam*, initiated in 2012 by contract, and converted to in-house in 2013. The purpose is an inventory of species composition, tree density and basal area, commercial wood volume, and snags and logs across most of JBLM's forest stands. The plot sampling protocol is designed to provide data for input to the Forest Projection System (FPS; Arney 2015), plus supplementary data for other forest management needs. As of September 2017, a total of 31,236 acres has been sampled. To date, commercial forest stands have been sampled proportionately more than their actual occurrence at JBLM. This may have an unknown but small effect on total standing stock estimates and underestimate the volume of minor, non-commercial species.

FPS is commercially available software, maintained by the Forest Biometrics Research Institute (Arney 2015), which supports spatially-explicit inventory and monitoring, projection of future stand growth, and scheduling of timber harvests and future stand exams. The initial database for JBLM has been established, using the new ecological stand boundaries and current information on soils, topography, wetlands, and forest stand attributes. As of 2017, we are still working with FPS to make sure it is being implemented properly to provide reliable standing stock, growth, and mortality values. Within the next few years, the Forestry Branch expects FPS to be used to guide almost all forest management activities.

In the last complete CFI analysis (1983-1993), standing stock was 1.27 billion board feet. Harvest (8.6 MMBF) was only 30% of net annual growth (25.6 MMBF, after accounting for mortality), meaning that the JBLM Forestry program harvested well below sustained yield, and had a large buffer in case of catastrophic timber losses (e.g., hurricane blowdown).

We expect the FPS results to show that standing stock has continued to grow, but at a reduced rate because many stands may be old enough to be past the *culmination of mean annual increment*, and because of the large but unknown increase in conifer mortality due to laminated root rot. The permanent removal of 721 acres of mature forest from the commercial forest base at several locations during the past few years due to military requirements would further decrease JBLM-wide standing stock, but this may have been offset by the addition of 1,195 acres of mostly plantation in the RTA formerly owned by a timber company.

As of 2015, installation-wide commercial wood volume was 95% Douglas-fir and 98% conifer, while basal area per acre was 85% Douglas-fir and 88% conifer (Table 13).

According to the ISI, most of JBLM's forest stands are well short of reaching owl nesting habitat targets, with the exception of understory/shrub cover and large snag density (Table 14). Looking at the three major Ecological Types, *site index* (King 1966), *basal area*, and *density* increase in the order prairie colonization forest > historic dry forest > historic moist forest, while canopy cover and average overstory tree dimensions decrease in the same order (Table 14). Prairie colonization stands have lower cumulative log lengths and snag densities than do historic dry and moist forests. Basal area and tree density are, not surprisingly, higher in stands not subject to logging than in regularly managed stands. Hardwoods occur on the most productive sites (highest site index) and have the greatest numbers of logs and snags.

Table 13. Basal area per acre and total net commercial wood volume, by species, in 2015 at Joint Base Lewis-McChord.*

Species	Basal Area (ft^2/acre)	Total Net Volume (MMBF)[1]
Douglas-fir	148	1,543
Western redcedar	5	49
Red alder	3	14
Black cottonwood	1	9
Bigleaf maple	3	8
Western hemlock	<1	3
Oregon white oak	1	1
Minor species[2]	<1	1
Total	159	1,628

*Fort Lewis portion only

[1]million board feet

[2]ponderosa pine, grand fir, cherry spp., Oregon ash, Pacific madrone, Sitka spruce, Pacific yew

In recent years, remote-sensing has been used to supplement ground inventory and monitoring measurements. LiDAR, flown in 2005 and 2010, was used to develop relationships between LiDAR metrics and stand structure attributes in the CFI plots (Strunk 2008, Stephens 2011). These relationships were then used to estimate installation-wide stand structure attributes (Table 15) and prepare installation-wide GIS raster layers. There was no significant change in any attribute between 2005 and 2010.

Stand Development

Tree seedlings are monitored on 1/50th-acre plots one year after planting to determine survival. A visual reconnaissance is conducted three years after planting, followed by additional plot monitoring five years after planting to determine if each reforestation site is adequately stocked with free-to-grow saplings.

High Value Conservation Forests

To comply with FSC certification, we must conduct regular monitoring on the condition of, and the effectiveness of measures to maintain and enhance, our High Conservation Value Forests (HCVFs; Forest Stewardship Council 2010). The condition monitoring must occur at a frequency and intensity appropriate for the scale and intensity of HCVF management and the relative complexity and fragility of the HCVFs. The effectiveness monitoring must be annual. We voluntary include Representative Sample Areas (RSAs) in this requirement.

Table 14. Structural attributes of the major forest types of Joint Base Lewis-McChord (2008-2012 Intensive Stand Inventory).

	Forest Type						
Attribute (mean ± 1 standard error)	Prairie Colonization	Historic Dry	Historic Moist	Hardwood	Unmanaged	Central Impact Area	Nisqually Floodplain
Number of stands	12	12	12	5	5	5	5
Basal area (feet^2/acre)[1]	158 ± 7	169 ± 7	186 ± 7	181 ± 11	229 ± 19	226 ± 31	213 ± 22
Density (stems/acre)							
commercial[1]	56 ± 6	64 ± 53	83 ± 8	91 ± 9	127 ± 23	84 ± 16	105 ± 19
precommercial[2]	79 ± 16	74 ± 20	99 ± 24	35 ± 14	56 ± 19	70 ± 20	90 ± 31
reproduction[3]	80 ± 11	63 ± 18	71 ± 21	5 ± 3	28 ± 10	49 ± 13	18 ± 10
Cover (%)							
overstory	39 ± 4	45 ± 4	46 ± 5	51 ± 4	55 ± 6	43 ± 7	55 ± 8
understory[4]	21 ± 2	23 ± 4	21 ± 3	47 ± 4	32 ± 7	23 ± 2	39 ± 6
shrub[5]	43 ± 3	63 ± 4	57 ± 3	53 ± 2	45 ± 4	28 ± 5	54 ± 4
ground[6]	66 ± 4	71 ± 3	62 ± 4	51 ± 6	56 ± 9	48 ± 6	44 ± 5
Average overstory tree[1]							
diameter (inches)	26 ± 1	24 ± 1	25 ± 1	26 ± 2	21 ± 2	29 ± 4	21 ± 3
height (feet)	137 ± 3	136 ± 3	142 ± 5	125 ± 7	122 ± 5	143 ± 18	125 ± 16
crown ratio (%)	42 ± 3	40 ± 2	39 ± 2	47 ± 5	36 ± 2	36 ± 4	44 ± 4
radial growth (inches)	0.42 ± 0.02	0.49 ± 0.04	0.46 ± 0.02	0.59 ± 0.12	0.48 ± 0.06	0.32 ± 0.06	0.52 ± 0.11
Site index (feet)[7]	123 ± 2	127 ± 2	135 ± 3	149 ± 8	135 ± 4	136 ± 10	121 ± 2
Log length (feet/acre)							
all logs[8]	278 ± 58	687 ± 119	539 ± 71	1132 ± 263	715 ± 263	365 ± 93	895 ± 151
large logs[9]	49 ± 17	100 ± 29	76 ± 20	141 ± 78	97 ± 40	75 ± 38	200 ± 54
Snag density (stems/acre)							
all snags[10]	2.9 ± 0.7	5.0 ± 0.7	5.8 ± 1.0	9.4 ± 2.0	6.6 ± 2.0	6.0 ± 2.8	3.2 ± 0.7
large snags[11]	0.4 ± 0.1	0.4 ± 0.1	0.6 ± 0.1	0.8 ± 0.2	0.6 ± 0.2	0.7 ± 0.3	0.6 ± 0.2

[1]stems ≥ 8.0 in dbh [2]stems 1.5 ft tall to 7.9 in dbh [3]stems < 1.5 ft tall [4]> 6 ft tall but below base of overstory canopy [5]18 in to 6 ft tall [6]0-18 in tall
[7]King 50-year (King 1966); measured 1999-2003 [8]≥ 10 in midpoint diameter and ≥ 10 ft long [9]≥ 24 in midpoint diameter and ≥ 20 ft long [10]≥ 10 in dbh and ≥ 10 ft tall [11]≥ 20 in dbh and ≥ 20 ft tall

Table 15. LiDAR estimates of forest structure, Joint Base Lewis-McChord*, 2005 and 2010, based on measurements from Continuous Forest Inventory plots (n = 112).

	2005		2010	
Attribute	Mean	SD[1]	Mean	SD[1]
Density (stems/acre)[2]	73	53	72	56
Basal area (ft^3/acre)[2]	152	92	156	92
Volume (board feet/acre)[2]	9,732	7,353	10,149	7,204
Canopy cover (%)[3]	77	14	82	9
Canopy height (ft)	92	38	88	39

*Fort Lewis portion only.

[1]Standard deviation

[2]Live trees ≥ 8.0 inches dbh

[3]Vegetation ≥ 6.5 feet tall

The monitoring takes three forms:

- *Slow, long-term change.* In the absence of active management and major natural disturbance, HCVFs will gradually change as a result of natural succession and the accumulation of small disturbances, such as individual-tree death. Periodic monitoring at multi-year intervals adequately documents these changes. Pine stand monitoring began in 2006 (remeasured in 2011; Foster 2008), oak stand monitoring in 2008 (Foster 2009), and monitoring of JBLM's only old-growth stand, Ellsworth Woods, in 1997 (Ahrens 1998) (remeasured in 2008 and 2016). For the rest of the HCVF types, long-term change is assessed by scheduling stand exams so that in any given 10-year period, a representative sample of each type is included.
- *Rapid, short-term change.* This type of change occurs in response to active management (e.g., ecological restoration), natural disturbances (e.g., wildfire, flooding), and prescribed fire. Monitoring occurs shortly after each such event. In the case of major natural disturbances, monitoring of the forest attributes most affected occurs as soon after each event as possible, to assess immediate effects. For example, following a wildfire in Ellsworth Woods in 2015, the monitoring plots located there were resurveyed in 2016 for live trees and snags. The long-term effects of restoration and major natural disturbances are evaluated at the next regularly-scheduled monitoring of long-term change.
- *Effectiveness of maintenance/enhancement measures.* Ecological restoration is an enhancement measure, and its monitoring is described above. Wildfire control is a maintenance measure, to prevent unexpected and usually negative ecological effects. If a wildfire occurs in an HCVF or RSA, its ecological impact is evaluated, both in the short- and long-term.

The ESMP for northern spotted owl habitat requires JBLM to inventory existing owl nesting/roosting, foraging, and dispersal habitat across the installation. This analysis has just been completed (Stephens 2017). A total of 3,293 acres was identified, including 19 core habitat areas (≥ 10 acres and totaling 275 acres) and numerous small pixels (95 x 95 feet). The locations

with the most amount of habitat are the Central Impact Area and Training Areas 13, 16, 19, and 22.

The geographic occurrence of laminated root rot (LLR) was estimated in 2012. Potential locations of infection centers were identified on aerial photographs (clusters of three or more fresh snags) and a contractor visited each location to verify LLR presence. Canopy gaps and clearcuts created specifically to try to contain infection centers were also identified. As new timber sales are planned, all canopy gaps created by LLR are identified.

Sustained Yield

No *sustained yield* harvest level, in the traditional forestry use of the term, is set for JBLM's forests because we are not managed like a typical profit-making forest ownership, or even a government ownership that provides revenue for public purposes. Rather, we assure that whatever harvest does occur is well below the maximum potential harvest that could occur. Currently, average annual timber harvest is 9.0 MMBF (Table 7), which is likely much less than current annual growth.

GOALS, OBJECTIVES, AND MANAGEMENT ACTIONS

This chapter describes goals, objectives, and management actions. Associated with each goal is the Desired Future Condition that indicates the successful achievement of that goal.

GOAL 1: Manage for a variety of forest stands to support military training

A specific goal of forestry management on JBLM is improvement, maintenance, and support of military training. Military training consists of four types:

Mounted: Mounted training includes all vehicle-based training, including *Strykers*, trucks, and *Humvees* (there are no tracked vehicles, such as tanks, on JBLM). Ideal areas for mounted training are savannas or grasslands. Within forested areas, vehicles are only allowed to traverse existing roads. Therefore, tree density management does not have a major influence on mounted training.

Dismounted: Dismounted mounted training involves maneuvering of soldiers on foot. In forested areas, foot soldiers can use a much denser stand than mounted units. Foot soldiers desire the overhead concealment from aerial observation offered by tree canopies, and the protection from projectiles provided by tree trunks. Soldiers prefer stands that minimize obstacles to movement and offer optimal horizontal sighting distance.

Artillery: Artillery includes howitzers, mortars, and rockets. Designated firing points must be free of trees in order to fire projectiles into the Artillery Impact Area.

Airborne: Aerial support of mounted and dismounted training is provided by fixed-wing (airplanes) and rotary-wing (helicopters) aircraft. Airplanes require large, tree-free drop zones for parachuting troops and supplies to ground units. Twelve drop zones on JBLM grasslands are currently designated. Helicopters require both tree-free grasslands and openings within forested areas for landing and takeoff.

Desired Future Conditions

- Average tree canopy cover is 60% or greater, to provide overhead concealment.
- For the majority of stands in each training area:
    - Average tree diameter is sufficient to provide cover from projectiles.
    - Areas of dense brush do not occupy the majority of the understory, to provide mostly unobstructed horizontal views.
- Slash piles and log accumulations are minimized, to provide for ease of troop movement.
- Drop zones in prairies and firing points/helicopter landings in forested areas are free of live trees and snags, to provide safe airdrops, artillery firing, and helicopter landing/takeoff.

Objective 1-1: Maintain vertical concealment.

Canopy cover is the proportion of the ground covered by the vertical projection of the outermost perimeter of tree crowns (note: overlapping tree crowns are accounted for, so cover ranges from 0 to 100%). When canopy cover is 60% or higher, equivalent to the definition of closed forests, concealment is high.

Management Action 1-1-1: Maintain five-year average stand canopy cover equal to or greater than 60% within the forested portion of each training area.

Where the baseline condition is less than 60% canopy cover, the existing level of healthy native tree species will be fully retained and allowed to mature. Where the baseline condition is greater than 60% canopy cover, commercial thinnings will not remove so many trees that average cover falls below 60%, unless specifically required for silvicultural reasons, ecological restoration, or military training requirements.

Objective 1-2: Maintain horizontal sighting distance.

Military trainers desire an average horizontal sighting distance in forests between 165 and 330 feet. This does not have to be everywhere in forest stands; dense areas of natural vegetation are acceptable. However, minimizing invasive species, especially Scotch broom, is desirable.

Management Action 1-2-1: Maintain average horizontal sighting distance between 165 and 330 feet for the majority of stands in each training area.

Native and non-native brush in the understory will be controlled using prescribed fire, mechanical controls, approved herbicides, and manual removal across substantial proportions of forest stands.

Objective 1-3: Minimize obstacles to soldier movement.

Forestry activities directly affect the ability of foot soldiers to maneuver through forest stands. Timber harvest operations have the greatest impact on maneuverability. Troop safety, area access, and environmental concerns are all factors in determining appropriate actions.

Management Action 1-3-1: Minimize accumulations of logging slash.

Large accumulations of slash are an impediment to troop movement. In timber sale contracts, loggers are required to haul felled trees to landings, where the branches, tops, and other unmerchantable portions are removed. This slash must be piled, then removed and disposed of. Slash left out in the woods and along skid trails will be lopped, scattered, and crushed within 12 inches of the ground. Additional slash cleanup will occur in areas of high troop use, near military improvements, and, to reduce fire danger, within 100 feet either side of roads.

Management Action 1-3-2: Remove hazard trees.

To ensure safety, during forest management activities, all snags and live hazardous trees that have the potential to reach drivable roads or troop assembly areas will be felled.

Management Action 1-3-4: Maintain timber sale roads.

Road maintenance is done to facilitate logging haul routes, but provides a secondary benefit to military vehicle movement. Timber sale roads will be maintained for vehicle passage, i.e., brushing, grading, shaping, obstruction removal, and rock application.

Objective 1-4: Prevent further encroachment of forest onto open training lands.

Open land (grasslands) and woodlands/savannas at grassland-forest margins are highly desirable for military training. However, in the absence of fire and other vegetation control methods, conifers will encroach on these areas, eventually converting them to conifer forest.

Management Action 1-4-1: During forest management activities, conifers encroaching onto grasslands and into woodlands and savannas at grassland margins will be considered for removal.

Encroaching conifers will be cut down or girdled, provided such actions are compatible with ecological restoration goals and the needs of wildlife (e.g., western gray squirrel). Range Support will determine the desired level of conifer removal on ranges and firing points. Forestry will not remove conifers in the Artillery Impact Area because of unexploded ordnance.

Objective 1-5: Provide specialized training needs.

The Forestry Branch supports the military mission by conducting prescribed burns for military trainers and providing timber sale support for construction projects.

From time to time, military trainers request special forest harvest activities to facilitate training, e.g., training lanes clear of trees within otherwise intact stands, removal of trees to provide clear projectile paths at firing points, and airfield approach zones free of trees in aircraft glide zones.

Management Action 1-5-1: Clear trees from designated areas to meet specific training requirements.

Examples include training lanes clear of trees within otherwise intact stands and removal of trees to create maneuver corridors between open lands currently separated by forest. Forestry can include stump removal in timber sales that implement this management action.

GOAL 2: Manage for retention of native biodiversity, including rare or unique flora and fauna

Army Regulation 200-1, 4-3 d (4) (a-c) requires:

- Promote biodiversity and ecosystem sustainability on Army lands and waters consistent with the mission and INRMP objectives.
- Manage flora and fauna consistent with accepted scientific principles and in accordance with applicable laws and regulations, and, where lands and waters are suitable, for conservation of indigenous flora and fauna.
- Manage habitat to conserve and enhance existing flora and fauna, and listed species, consistent with the Army goal to conserve, protect, and sustain biological diversity while supporting the accomplishment of the military mission.

JBLM manages for biodiversity at four hierarchical levels:

- Genetic diversity – the variety of different *genotypes* in a species' *population.*
- Species diversity – the variety of different species in a given area.
- *Community* diversity – the variety of different plant communities in a given area.

- *Ecosystem* diversity – the variety of different ecosystems in a given area.

Biodiversity conservation requires action at different spatial scales, from individual trees to the entire JBLM landscape. Forestry management operates primarily at the *forest stand* level. Within stands, management actions may leave or remove, or encourage or discourage growth of, individual trees or clumps of trees. Clusters of adjacent stands are sometimes managed as a unit. At the landscape level, forest fragmentation and connectivity are important considerations.

Desired Future Conditions (DFCs)

- Where consistent with military training, forest history, and site capability:
  - Within stands – multiple canopy layers, multiple tree species, appropriate understory vegetation in specific stands (e.g., for western gray squirrel or northern spotted owl).
  - Between stands and across the JBLM landscape – multiple forest types and stand structures.

Objective 2-1: Identify, maintain, and restore stands dominated by Oregon white oak and ponderosa pine.

Forest stands with a significant component (at least 25% overstory cover) of oak and/or pine increase biodiversity at the species, community, and landscape levels. Without management intervention, these stands will continue to degrade ecologically, and, eventually, will nearly disappear from the landscape. To avoid this, most existing oak and pine stands should be protected from threats such as overtopping by invading conifers, invasion by non-native shrubs, and catastrophic fire. In addition, priority oak and pine stands should undergo active ecological restoration to move their structure and species composition toward conditions more favorable to wildlife and the regeneration of oak and pine. In general, these conditions are similar to presumed mid-19th century (pre-settlement) conditions, and include reintroduction of fire as an ecological process.

Management Action 2-1-1: Identify and map plant communities with at least 25% overstory cover of Oregon white oak and ponderosa pine.

The locations of all oak communities on JBLM have been mapped, with the exception of Douglas-fir/oak, which is difficult to identify on aerial photographs. New remote-sensing techniques may soon permit this mapping to occur. The locations of all native ponderosa pine communities on JBLM have been mapped, as has the geographic distribution of ponderosa pine in the southern Puget Lowland.

Management Action 2-1-2: For each oak and pine type, define its DFC, in coordination with JBLM Fish & Wildlife, and implement a restoration strategy to achieve the DFC.

Development of DFCs will consider current condition and threats, presumed pre-settlement condition, past and on-going restoration actions, constraints on carrying out restoration actions, the needs of associated wildlife and military training, and, at the landscape level, fragmentation, connectivity, and the desired proportions of the various community types. The restoration strategy will identify priority oak and pine stands for treatment, and the restoration actions to be carried out in each.

Management Action 2-1-3: Carry out ecological restoration in each priority stand, as determined by the restoration strategy.

Forestry, Fish & Wildlife, and Range Support will jointly implement the restoration strategy. Restoration actions will be accomplished by contract or in-house.

Management Action 2-1-4: Monitor the results of restoration at each site.

Oak and pine monitoring plots will be remeasured by Forestry at regular intervals (e.g., every five or ten years). If DFCs are not being attained, the DFCs and restoration strategy will be revised accordingly.

Objective 2-2: Identify and conserve minor tree species and uncommon or unique plant species and communities.

Although of little or no commercial value, Oregon white oak, ponderosa pine, black cottonwood, and other minor species increase species diversity, promote variation in stand structure, and provide food sources and nesting habitat for wildlife. In some cases, minor tree species (Sitka spruce, grand fir, lodgepole pine, madrone) may dominate or co-dominate forest stands, contributing to community diversity. Uncommon or rare understory plant species (e.g., small-flowered trillium) and understory plant communities (e.g., with Oregon oxalis [*Oxalis oregana*] or devil's club [*Oplopanax horridum*]) contribute to species and community diversity.

Management Action 2-2-1: Non-commercial and minor tree species will not be marked for cutting in timber sales or ecological restoration projects without specific justification.

Normally, Douglas-fir is the only species cut in JBLM timber sales, but sometimes red alder is cut, and occasionally bigleaf maple. Western hemlock, western redcedar, and black cottonwood may be marked, if necessary, for silvicultural reasons (e.g., forest health). Marking of ponderosa pine, Oregon white oak, Pacific madrone, and minor species will occur only when required for ecological restoration or to meet military training needs, as documented in the silvicultural prescription for each sale.

Management Action 2-2-2: During timber sales, consider removing Douglas-fir that are overtopping non-commercial or minor, shade-intolerant tree species.

Forest Service research at JBLM has shown that even severely suppressed Oregon white oaks are capable of release, i.e., crown rebuilding (via *epicormic* branches) and sudden increases in radial and height growth if competing overstory conifers are removed (Devine and Harrington 2006). Ponderosa pines growing in dense Douglas-fir stands have reduced growth and narrow, short crowns; their releasability is unknown. In closed (more than 60% canopy cover) stands, lodgepole pine and madrone require some removal of adjacent overstory trees to undergo release.

Management Action 2-2-3: Identify and conserve uncommon or unique plant communities.

Stands dominated by minor tree species (e.g., Sitka spruce in several forested wetlands), or with uncommon or unique understory plant communities, will be mapped. This mapping

has been completed as part of the High Conservation Value Forest (HCVF) analysis (Figure 14) carried out as part of FSC certification. All stands identified in the analysis will be protected from management intervention, except for ecological restoration or fire/pathogen control.

Objective 2-3: Identify and conserve forest stands with old-growth characteristics.

Forest stands with old-growth characteristics (e.g., large old trees, large snags and logs) are rare at JBLM and in the Puget Lowlands. Under the requirements of JBLM's FSC certification, these stands must be mapped and protected.

Management Action 2-3-1: Identify, map, and conserve old-growth stands.

This mapping has been completed as part of the HCVF analysis (Figure 14) associated with FSC certification. All stands identified in the analysis will be protected from management intervention, except for ecological restoration or fire/pathogen control.

Management Action 2-3-2: Protect legacy trees in all forest stands.

Outside of old-growth, legacy trees (large, old Douglas-fir with asymmetrical crowns and – usually – bark fire char at the base) are present here and there in JBLM's forests. These trees are left over from the previous stand or, in prairie colonization forests, were formerly isolated trees in grasslands. Unless specifically required for military reasons, or being hazard trees, legacy trees will not be marked for cutting during timber harvest.

Objective 2-4: Maintain and increase habitat for key forest fauna.

Management Action 2-4-1: In stands identified as western gray squirrel habitat, consult with the JBLM Fish & Wildlife Program to develop forest management actions that help create key squirrel habitat characteristics.

As the western gray squirrel population on JBLM continues to increase in numbers and geographic extent, an increasing proportion of managed stands may contain core nesting, habitat that may be excluded from logging until the next sale entry or later. In addition, Fish & Wildlife personnel may sometimes mark trees to help create the patchiness in tree density and size that squirrels prefer. In some cases, mechanical or chemical brush control may be needed to maintain the open understories where squirrels forage. Finally, logging does will not occur between March 1 and August 31 within occupied squirrel habitat.

Management Action 2-4-2: In all stands scheduled for forestry management actions, consult with the JBLM Fish & Wildlife Program to identify and protect eagle/raptor nests and heron rookeries.

Protection of eagle nests and roosting areas is required by the Bald Eagle Protection Act. In response, JBLM maintains seasonal buffers around nests and roosting areas that limit military training and forestry management actions to prevent disturbance to eagles. Forest stands scheduled for timber harvest will be surveyed for raptor nests and the trees these nests occur in will not be marked for cutting. Protection from disturbance by forestry management actions will also be provided to any identified heron rookeries.

Objective 2-5: Maintain riparian buffers to minimize impacts of forest management on riparian ecosystems, and on bald eagles and listed fish species.

Management Action 2-5-1: Designate riparian buffer zones around various lakes, streams, and wetlands on JBLM.

This designation must take into account the type of water body (lake, stream, wetland, spring), whether or not a single buffer or dual buffers (inner/outer) is needed, the management restrictions associated with each buffer, and the minimum U.S. buffer requirements of the FSC. Currently, JBLM Forestry uses 75-foot-wide inner buffers where no logging occurs and 100-foot-wide outer buffers where use of heavy equipment during logging must be minimized.

Management Action 2-4-2: Provide protection from disturbance to wetlands containing water howellia.

Forest management actions must not disturb water howellia habitat (certain wetlands), in accordance with the ESMP for water howellia.

GOAL 3: Manage to maintain site productivity

Site productivity is the capability of a given area of land to support tree growth. In forestry, it is measured as *site index*. Ecologically, it is measured as *net primary productivity* per unit ground area or leaf area. Productivity is affected by soil, climate, topography, and aspect. Soil is the factor that is most influenced by forest management (Powers 1999). Erosion can cause direct loss of organic matter and nutrients from soils. Compaction reduces soil *porosity*, which increases erosion, reduces soil gas exchange, and decreases activity of aerobic soil organisms. *Litterfall*, both woody (twigs, branches, boles, roots) and non-woody (foliage, cones) is vital to sustain site productivity through its effects on soil structure, water-holding capacity, the activity of soil organisms, and nutrient stocks (Powers 1999).

Desired Future Conditions

- Maintain inherent ability of forest sites to grow trees.
- Soil erosion and compaction are uncommon and localized.

Objective 3-1: Avoid excessive disturbance to soils and forest floors during forest management activities.

JBLM's soils are generally flat, rocky, and highly resistant to erosion. Thus, erosion is a local phenomenon restricted to some road crossings of streams or wetlands, or to wintertime road use and heavy machinery operation on the occasional steep slope. A high proportion of organic matter and plant-available nutrients is located in the forest floor and the uppermost A soil horizon. Heavy machinery operation can remove these layers or cause localized soil compaction, particularly when soils are saturated, both of which can reduce tree growth.

Management Action 3-1-1: Logging operations will not occur on slopes greater than 50% unless specialized equipment that minimizes ground disturbance is used.

Use of mechanized ground equipment (wheeled or tracked) can cause substantial erosion on steep slopes, especially when skid trails are oriented perpendicular to the slope. However, new developments in logging machinery allow tree harvest on steep slopes with little erosion. Exceptions to the 50% rule may occur on a case-by-case basis.

Management Action 3-1-2: Logging will not occur in historical moist forests during the rainy season unless tracked machines are used (i.e., no rubber-tired skidders). JBLM Forestry may issue a written exception if skid-trail rutting is less than 12 inches.

Observations at JBLM have indicated that use of rubber-tired skidders during logging on soils underlying historic moist forests can cause compaction and rutting when soils are saturated, i.e., during the rainy season (typically November to May). The use of tracked skidders is preferable because the lower ground pressure reduces compaction and rutting.

Management Action 3-1-3: Logging, road construction, and skid trails will not occur in forested wetlands without written justification.

Possible exceptions could be salvage and access to isolated, non-wetland stands.

Management Action 3-1-4: Maintain timber sale roads, as necessary, to facilitate access by logging equipment and Forestry fire trucks.

During the rainy season, timber sale roads in the forested areas of JBLM can become rutted, with accelerated erosion and runoff, after passage of heavy equipment such as logging trucks and Strykers. If a road needs repair to facilitate logging or other forestry activities, appropriate repairs will be carried out, e.g., grading, *waterbars*, rocking.

Management Action 3-1-5: Prevent vehicle use of skid trails following timber sales.

Following logging, skid trails can quickly be converted to unplanned roads by repeated military vehicle use. They can also act as channels for runoff, leading to soil erosion. After each timber sale, all skid trails will be blocked with dirt or woody debris, and, if necessary, waterbarred.

Objective 3-2: Maintain soil structure and forest nutrient cycles by retaining sufficient dead organic matter in forest stands.

The role of dead wood in the structure and functioning of forest ecosystems is discussed by Foster (2010). Non-woody litter (e.g., leaves) has higher nutrient concentrations than woody litter, so it is especially important in forest nutrient cycling. Chronic removal of woody and non-woody litter from forests can potentially cause long-term declines in productivity. Productivity also diminishes following severe wildfires that remove most of the organic matter from a site.

Management Action 3-2-1: Adopt management practices that encourage retention and accumulation of large dead wood.

Current forest stands on JBLM have little dead wood legacy due to past logging practices or because they are prairie colonization forest. Thus, to the extent possible, what dead wood is present should be retained. Management practices that encourage this include no

felling of snags unless they are a hazard to logging operations or troops, no removal of large logs as part of timber sales, and in some situations (e.g., certain ecological restoration projects), deliberate snag creation.

Management Action 3-2-2: Do not use "clean logging" timber harvest.

Clean logging's objective is to minimize slash left in the woods. To the extent possible, logging slash should be left on site as long as it does not conflict with Management Action 1-3-1. For example, some of the slash, at landings or left in the woods, may be used to armor skid trails to minimize compaction to the soil. The combined purpose of Management Actions 1-3-1 and 3-2-2 is to retain slash in the woods but prevent large accumulations that inhibit troop movement. Also, in western gray squirrel habitat, areas without slash should be left.

Management Action 3-2-3: Salvage excessive woody debris blocking roads following major disturbances.

Two major ice storms in the last 15 years (1996 and 2012) have caused major tree uprooting and loss of tree tops and branches across JBLM. The resulting debris blocks roads and increases fire risk adjacent to roads due to excessive fuels. Salvage logging can remove recently fallen trees.

GOAL 4: Manage to reduce the risk of stand-replacement wildfire

Stand-replacement fires kill most of the overstory trees in a stand, at least temporarily eliminating their value to biodiversity and military training. Today, in the absence of fire as a usable management tool in most forest stands, silvicultural activities can be used instead to minimize the risk of fires becoming stand-replacement, e.g., by eliminating "ladder" fuels that can carry ground fires into the canopy.

Desired Future Conditions

- Stand-replacement wildfires are rare on JBLM.
- All prescribed burns remain within prescription.

Objective 4-1: Reduce excessive accumulations of fuels following logging and natural disturbances.

The reduction of logging slash to enhance troop movement through forest stands (Management Action 1-3-2) will largely fulfill this objective. In addition, natural disturbances such as ice storms and windthrow can generate excessive fuels, independent of forest management activities.

Management Action 4-1-1: Carry out Management Action 1-3-2.

Reduction of slash following timber sales reduces fuels, and hence fire danger.

Management Action 4-1-3: Carry out Management Action 3-2-3.

Presence of vehicles and soldiers means that the risk of fire ignition is higher along roadsides and in bivouac and staging areas than elsewhere in training areas.

Objective 4-2: Manage stand structure to reduce wildfire spread.

The amount and arrangement of fuels within forest stands have a large impact on the rate of wildfire spread. Fuel loading and distribution can be altered directly through silvicultural treatments or by judicious use of prescribed fire.

Management Action 4-2-1: Use prescribed fire to remove ladder fuels and decrease the continuity between surface fuels and canopy fuels.

In woodlands and savannas, prescribed fire can safely be used to reduce fuel loading and continuity without killing many overstory trees or escaping burn boundaries. In some cases, hotter burns can be used to deliberately kill some of the overstory trees.

Management Action 4-2-2: During ecological restoration, implement mechanical treatments to remove ladder fuels and decrease the continuity between surface fuels and canopy fuels.

In all forest types, mechanical treatments (e.g., logging, tree girdling, brush mowing) can be used to reduce fuel loading and continuity. In some cases, rearrangement of existing fuel loads will reduce continuity and thus fire hazard.

Objective 4-3: Develop a wildfire risk model for JBLM's forests.

All other factors being equal, the major forest types on JBLM have different risks of fire ignition and different rates of spread once a fire starts. The predictions of a wildfire risk model can help determine stand treatments under Objective 4-2, as well as what types of suppression resources will be needed if a fire starts.

Management Action 4-2-1: Use an existing computer model (LANDIS-II; LaFlower et al. 2015) to estimate risk of ignition and rate of spread in each major forest type on JBLM.

At a minimum, the fire risk model must consider fuel continuity, fuel moisture, fuel load, terrain-associated risks, and comprehensive wildfire risk.

GOAL 5: Manage to reduce the risk of insect and disease epidemics

As discussed in the Background section of this plan, laminated root rot is currently causing widespread Douglas-fir decline and mortality at JBLM. As a result, substantial forest area has reduced value for military training, commercial wood volume is being lost, and the structure of infected stands is being altered.

Desired Future Condition

- Tree decline and mortality caused by insects and diseases are localized, without epidemics affecting large portions of the JBLM landscape.

Objective 5-1: Periodically survey for insect and disease presence and tree mortality.

Forestry did not anticipate the current outbreak of LRR because we did not conduct surveys of our forests for insects and diseases. Thus, we did not begin control actions until the disease was already widespread. This problem can be avoided by instituting recurrent surveys for insects and diseases.

Management Action 5-1-1: When forest management activities are planned (e.g., stand exams prior to timber sales), pockets of tree decline and mortality will be mapped and the causal agent(s) identified.

Early warning is important to anticipating and controlling insects and diseases. This is best accomplished by always being on the lookout for clusters of tree decline and mortality, and if found, the causal agent should be identified. For example, we are currently finding that some mortality pockets initially ascribed to root rot are the result of other fungal diseases or insects.

Objective 5-2: On a site-specific basis, use resistant or immune tree species or *genotypes* to reduce persistence and spread of laminated root rot.

The forestry literature indicates that only hardwood species are immune to laminated root rot; all conifer species are susceptible, though some species are more resistant than others. There also appear to be individual Douglas-fir that survive in root rot pockets, implying a genetic component to resistance. The use of resistant and immune species in reforestation of root rot pockets should slow the spread of the disease because it will no longer have a "free hand" in uniform stands of highly-susceptible Douglas-fir.

Management Action 5-2-1: Incorporate planting of resistant and immune species into reforestation of root rot pockets, with each species matched to appropriate sites.

Which resistant or immune species can be planted depends on site characteristics. For example, ponderosa pine is a good choice for prairie colonization forest sites, provided local (JBLM) seed source is used, and has the added benefit of being a food source for western gray squirrel. Red alder is a good choice for historic moist forests where soils are moist enough year-round to support this species.

GOAL 6: Manage to minimize the impacts of non-native plant species

The non-native shrub, Scotch broom, is hindering effective reforestation at JBLM, resulting in loss of land available for military training and a loss of forest habitat for native plants and animals. Various forestry tools are available to control non-native plant species, including manual, mechanical, chemical, and fire methods.

Desired Future Condition

- Scotch broom does not adversely affect seedling (planted or natural) growth and survival in most areas with significant regeneration present.
- Other non-native plants do not dominate forest stand understories.

Objective 6-1: Control Scotch broom in reforested areas so that trees are *free to grow*.

Many forest plantations created by clearcutting, and deliberately-created canopy gaps, are currently dominated by Scotch broom, with high mortality of conifer regeneration (planted and natural) and poor growth of most surviving seedlings/saplings due to competition from dense, tall Scotch broom. Control of Scotch broom is essential in these areas if tree regeneration is to be free to grow.

Management Action 6-1-1: Monitor size and extent of Scotch broom occupation in plantations and prescribe appropriate release treatments.

Immediately post-harvest, clearings scheduled for reforestation will be surveyed for presence/density of Scotch broom, and release treatments prescribed to control it. This survey and control process will be repeated post-planting, if needed.

Objective 6-2: Control persistent Scotch broom infestations where feasible, especially in logging landings.

Because most logging landings are reused in subsequent timber sales, no planting or brush control has occurred in them. Most of these landings convert to dense Scotch broom, making them broom seed sources for spread of broom into the surrounding stand.

Management Action 6-2-1: Control Scotch broom in logging landings.

During pre-sale planning and post-sale assessment, landing sites should be identified for future logging use. If a landing will be used at the next harvest entry and has been invaded by Scotch broom, it should be mapped and the broom controlled to prevent further broom seed being added to the soil seed bank. Applying grass seed at landings should also be explored as a means of controlling broom through competition.

Objective 6-3: Identify and locally control English ivy, English holly, and other invasive, non-native species.

English ivy is a common ornamental plant in urban and suburban areas of western Washington. In natural landscapes, however, it is considered an invasive weed that can dominate forest understories, eliminating most native plants, and can climb trees, where it is more likely to flower and produce seeds that will be dispersed by birds. Ivy has appeared across many acres on JBLM during the past decade and if left unchecked, will continue to spread and reduce native understory biodiversity. English holly is a shade-tolerant clonal shrub whose red fruits are also spread by birds. Over time, it can form thickets that locally exclude native forest understory vegetation.

Management Action 6-3-1: English ivy and English holly infestations in the training areas will be controlled to the extent feasible.

Nascent ivy infestations in the training areas will be mapped. Isolated infestations deep within the training areas, i.e., far from the installation boundary, will be controlled first, followed by control of infestations closer to the boundary. Holly stems and clumps will be controlled gradually over time, as it is widespread across most JBLM's forested area.

Management Action 6-3-2: Occurrences of other invasive, non-native species will be controlled wherever found.

The most problematic of these species are periwinkle, archangel, creeping St. John's wort, English laurel, spurge laurel, Japanese knotweed, and European privet. Knotweed spreads especially fast and spurge laurel is toxic to the touch.

GOAL 7: Manage to protect cultural resources, including traditional uses by Native Americans

Cultural resources have strong legal protection under Federal law. At JBLM, there are abundant historic and pre-historic sites, many within forested areas. These sites must be located and protected until they can be evaluated for their cultural significance. The Treaty of Medicine Creek, made in 1854 between the United States and nine tribes, provides for the continued use by tribal members of ceded lands for hunting and gathering of cultural plants.

Desired Future Condition

- Cultural sites in JBLM's forests are not disturbed by forest management activities.

Objective 7-1: Identify and protect cultural and historic resources prior to and during proposed forest management activities.

Management Action 7-1-1: JBLM Forestry will fund cultural resource surveys of all areas planned for forest management activities.

JBLM Forestry funds cultural resource surveys of upcoming timber sale areas. These surveys will continue in the future.

Management Action 7-1-2: JBLM Forestry will coordinate with JBLM Cultural Resources to identify all cultural sites and issues on areas planned for forest management activities.

Forestry's current policy of early coordination of proposed forest management activities with Cultural Resources staff will continue.

Objective 7-2: Maintain communication with JBLM treaty tribes on proposed forest management activities.

Management Action 7-2-1: Through the JBLM Cultural Resources Program, JBLM treaty tribes provide input on forest management activities.

In the past, Forestry has been inconsistent about sharing planning documents with treaty tribes. In the future, all planning documents, including this forest management plan, will be sent to tribes for comment.

Objective 7-3: Provide opportunities for tribal use of traditional forest resources.

Management Action 7-3-1: JBLM Forestry will make cultural plant material available for use by treaty Tribes.

JBLM Forestry will notify Tribal representatives when opportunities for collecting cultural plant materials (e.g., cedar bark) occur, such as in clearcuts done for construction projects

or other mission-driven reasons. Such use will be compatible with the ecological goals and objectives of JBLM forest management.

Management Action 7-3-2: On request from Tribal officials, JBLM Forestry will grant permission to cut firewood in designated areas for elders and traditional uses.

For many years, Forestry has allowed Tribal elders to cut firewood on JBLM for personal use, and for Tribes to cut firewood for traditional cultural uses such as sweat lodges and smoking meat and fish. This policy will continue.

GOAL 8: Manage to provide public benefits

While there is no mandate to provide forest products other than to the military, including the public, there are opportunities within JBLM to provide some benefits.

Desired Future Condition

- Consistent with the primary mission of military training, provide a continuous supply of commercial forest products.

Objective 8-1: Maintain a sustainable timber sale program for commercial products.

There has been an active timber sale program on JBLM for over 50 years. Maintaining an ongoing timber sale program can be achieved by appropriate management activities contained within this document. The program provides jobs and wages to local logging companies and mills. During the past five years, the program has generated $4.15 million in revenue for natural resource management on Army installations and $2.73 million in revenue to local counties for roads and schools.

Management Action 8-1-1: Create, identify, and maintain a database of harvest units available for commercial harvest entry.

This database has been established within the Forest Projection System.

Management Action 8-1-2: Continue the existing relationship with the USACE to administer the sales of timber and oversee logging operations and contract administration.

After Forestry has selected and marked which trees will be harvested, the USACE takes the sale information and sets up timber sale auctions. After award, the USACE oversees all sales contract administration until completion of harvest. This relationship with the USACE frees up Forestry to concentrate on laying out sales and managing JBLM's forests for various military and ecological objectives. Otherwise, Forestry would have to develop in-house expertise and hire more staff to administer timber sales.

Objective 8-2: Maintain a commercial and personal-use firewood program.

Firewood sales, both commercial and personal, are a very small portion of the timber-related revenue generated on JBLM. The ability to provide JBLM and surrounding communities with a low-cost source of firewood far outweighs the small revenue derived from firewood sales.

Management Action #8-2-1: Maintain the relationship with the USACE to administer the firewood program.

The USACE has been charged with administering the firewood program on behalf of Forestry. They are responsible for establishing the firewood decks, issuing permits, and collecting money. Because the USACE is set up to collect money from sale of forest products, this relieves Forestry of having to develop this capability.

GOAL 9: Maintain third-party certification as a sustainable forest

JBLM's forests are now in their sixteenth year of Forest Stewardship Council (FSC) certification as a sustainable forestry operation. Maintaining this certification is one objective of the JBLM Installation Sustainability Program. In addition, FSC audits provide an opportunity for outside experts to provide feedback to the Forestry Branch on how to make our program better.

Desired Future Condition

- JBLM Forestry Branch remains FSC-certified into the foreseeable future.

Objective 9-1: Undergo periodic audits to maintain certification.

FSC audits consist of two types: recertification audits every five years and annual audits to assure compliance with certification criteria.

Management Action 9-1-1: Schedule and fund annual FSC audits and, every five years, FSC recertification audits.

Objective 9-2: Fulfill certification requirements and respond to certification observations.

Each FSC audit produces two kinds of findings: Corrective Action Requests (CARs), which are actions Forestry is required to do – within a specified timeframe – to maintain certification, and Observations, which are non-mandatory actions suggested by the auditors to improve our operations, or which may lead, in the future, to CARs.

Management Action 9-2-1: The Forestry Branch will respond in a timely fashion to all FSC CARs and Observations.

Timely response to CARs avoids potential loss of certification. In addition, it is Forestry policy to respond to all Observations, regardless of whether or not we choose to implement them, because these offer the opportunity to consider aspects of our operations that may be more apparent to outside observers than to our staff.

Objective 9-3: Monitor the social and economic impacts of JBLM forest management. (This is a requirement of FSC certification.)

Management Action 9-3-1: At regular intervals, collect data on social and economic impacts.

A moderately detailed analysis of these impacts was carried out in 2012 (Resource Dimensions 2012). Portions of this analysis will periodically be repeated to determine

trends in impacts and whether or not there should be consequent changes in management practices. A 2017 analysis is currently underway, by contract.

GOAL 10: Manage for long-term creation of northern spotted owl habitat

This objective is driven by a new federal rule whereby the U.S. Fish and Wildlife Service exempted JBLM from re-designation of spotted owl critical habitat. To secure this exemption, JBLM prepared an ESMP for northern spotted owl critical habitat (US Army 2012) that describes management actions we are required to undertake to provide a net benefit to spotted owl habitat within an 11,560-acre Owl Focus Area in the RTA.

Desired Future Condition

- Designated stands on JBLM steadily move towards the desired characteristics of owl nesting, foraging, roosting, and dispersal habitat.

Objective 10-1: Emphasize development of owl habitat as large, contiguous forest blocks.

Mated spotted owl pairs in the northern part of their range require large, contiguous blocks of late-successional forest for suitable nesting and roosting habitat. The acreage requirements for foraging and dispersal habitat are smaller, but still substantial.

Management Action 10-1-1: Within the Owl Focus Area, identify at least one block of potential owl nesting/roosting/foraging habitat and one block of potential owl foraging/ dispersal habitat.

Objective 10-2: Use the Primary Constituent Elements (PCEs) in the Final Rule for Northern Spotted Owl Critical Habitat as the target stand structural characteristics for the various types of owl habitat.

The Final Rule lays out the PCEs in the Federal Register (Vol. 77, No. 233, pages 71875-72069). These PCEs serve as long-term goals for stand structure in the Owl Focus Area.

Management Action 10-2-1: Assign the appropriate PCEs to each stand in the Owl Focus Area, depending on the type of owl habitat it is intended to provide.

Objective 10-3: Use silvicultural treatments to manipulate forest stands in the Owl Focus Area to accelerate the development of owl habitat over what would occur without intervention.

The forestry literature indicates that human intervention in young stands can hasten the development of late-successional forest characteristics compared to natural succession alone. For example, following commercial thinning, the residual trees usually increase their growth rate. As a result, large trees, snags, and logs appear earlier in stand development.

Management Action 10-3-1: Implement silvicultural prescriptions within individual stands that favor the development of late-successional stand structure.

Multiple, landscape-scale experiments in the Pacific Northwest are examining the ability of various silvicultural treatments to hasten the development of late-successional habitat. These experiments have indicated that treatments such as variable-density thinning and

"skips and gaps" can increase understory and midstory species diversity, accelerate overstory tree growth rates, and create vertical layering and horizontal heterogeneity at a faster pace than untreated controls.

Objective 10-4: Periodically monitor the development of late-successional forest habitat.

Standard stand exams do not measure all of the owl PCEs. Therefore, separate monitoring of stand development in owl Focus Areas must be carried out.

Management Action 10-4-1: Use light detection and ranging (LiDAR) remote sensing to map current owl nesting/roosting, foraging, and dispersal habitat on JBLM.

This analysis was recently completed (Stephens 2017). It indicated that in 2010, there were 1,839 acres of high-quality nesting/roosting habitat, 32,265 acres of marginal nesting/roosting/foraging habitat, and 3,293 acres of simple foraging/dispersal habitat on JBLM. Most of these acres, however, were small and widely scattered, and only 19 focal areas (10 or more adjacent, suitable acres) were identified.

Management Action 10-4-2: Accelerate the rate at which stand exams are conducted within Owl Focus Area stands, and each time, make sure that all PCEs are measured.

Standard stand exams do not measure cover by layer, *canopy lift*, or other stand structure attributes diagnostic of owl habitat.

ECOSYSTEM MANAGEMENT GUIDANCE

In this chapter, general guidance for managing the major forest types on JBLM is laid out. For each type, a vision is presented, followed by guidelines to help us achieve that vision. Guidelines are not absolutes: exceptions can and will occur following site-specific analysis.

CONIFER-DOMINATED STANDS

VISION

Initiate structural diversity (vertical and horizontal) in young stands. Accelerate development of structural diversity and species diversity, and of late-successional structural characteristics (large overstory trees, snags, logs) in mature stands. Maintain or develop stand features that are desirable for military training.

GUIDELINES

- In moist forests where the proportion of shade-tolerant species in the overstory is less than 25%:
  - If shade-tolerant regeneration is present, encourage its development by thinning the overstory.
  - If shade-tolerant regeneration is lacking, thin the overstory and underplant shade-tolerant species.
- Primary silvicultural methods are uneven-aged.
- Use variable-density thinning to:
  - Increase *vertical diversity* (i.e., number of canopy layers).
  - Increase *horizontal diversity* (i.e., spatial variation in stem density, tree diameter, and species composition).
  - Increase direct sunlight to natural regeneration.
- Do not cut hardwood or minor conifer species without written justification.
- Retain and protect remnant late-successional features (i.e., large old trees, large snags, large logs).
- Consider planting where natural regeneration is scarce or missing.
- Conduct site preparation if heavy natural brush or Scotch broom is present.
- Consider precommercial thinning in young stands.
- At the landscape level, maintain average canopy cover of 60%.

MIXED STANDS

VISION

Same as for conifer-dominated stands, plus: Maintain the hardwood component because these species are immune to laminated root rot and contribute to wildlife habitat and spatially heterogeneous stand structure.

GUIDELINES

Same as for conifer-dominated stands, except:

- In moist forests where the proportion of shade-tolerant species in the coniferous overstory is less than 50%:
  - If shade-tolerant regeneration is present, encourage its development by thinning the overstory.
  - If shade-tolerant regeneration is lacking, thin the overstory and underplant shade-tolerant species

RED ALDER-DOMINATED STANDS

VISION

At the landscape level, maintain the current proportion (??%) of alder-dominated stands in moist forests.

GUIDELINES

- Where managed, silviculture is even-aged, to encourage maximum growth of this high-value species.
- Reforest promptly to restore military hiding cover.

OAK STANDS

VISION

At the landscape level, maintain the existing component of oak-dominated stands in prairie colonization forests. Enhance the ecological status of degraded stands.

GUIDELINES

- Increase dominance of oak through removal of overtopping Douglas-fir.
- Increase average oak diameter and crown spread by thinning dense oak stands.
- Diversify age- and size-classes in young, even-age oak stands through thinning.
- In oak savanna and oak-dominant stands, reduce native brush and control Scotch broom.
- Increase proportions of oak savanna, oak-dominant, and oak-conifer stands through thinning young oak stands and removal of Douglas-fir.
- Maintain open understory as a key habitat feature for western gray squirrels.

PINE STANDS

VISION

At the landscape level, maintain the existing component of pine-dominated stands in prairie colonization forests. Enhance ecological status of degraded stands.

GUIDELINES

- Increase dominance of pine through removal of overtopping Douglas-fir.
- Increase average pine diameter and height by thinning dense pine stands.
- Diversify age- and size-classes in young, even-age stands through thinning.
- Underburn stands to reduce native brush and control Scotch broom.

NORTHERN SPOTTED OWL HABITAT

VISION

Emphasize creation of northern spotted owl nesting, roosting, and foraging habitat, primarily in the Owl Focus Area. After stands reach desirable structural diversity, allow late-successional characteristics to continue developing without active management until an old-growth condition is achieved.

GUIDELINES

- Emphasize development of owl habitat in larger, contiguous blocks than individual forest stands.
- Emphasize development of stands with multiple canopy layers, high basal area, large live trees with a high incidence of deformity, large snags and logs, and sufficient open space below the canopy for spotted owls to fly.

WETLANDS AND RIPARIAN ZONES

VISION

Protect and maintain wetland and riparian ecosystems and their functions, including water quality and habitat for aquatic and terrestrial life.

GUIDELINES

- Create and maintain inner and outer buffer zones around all wetlands, streams, and lakes.
- On the Nisqually River floodplain and lower Muck Creek, and in inner buffer zones, no commercial timber harvest unless part of ecological restoration.
- Provide special management, in consultation with JBLM Fish and Wildlife, for forested wetlands containing listed species or species of concern.

FORESTS WITH HIGH CONSERVATION VALUE

VISION

All high-value conservation value forests (HVCFs) receive protection from uses that would compromise their unique values.

GUIDELINES

- In old-growth and unmanaged reference stands, no disturbance of any kind, except wildfire control and control of non-native species.
- In stands dominated by minor species, management intervention only when necessary, to preserve stand integrity.
- Manage oak and pine stands for western gray squirrel habitat requirements.

SCOTCH BROOM

VISION

At the landscape level, minimize area of Scotch broom dominance.

GUIDELINES

- Control broom in forest plantations until tree regeneration is free to grow.
- Control broom in oak and pine stands.
- Control broom in logging landings and along forest roads.

LAMINATED ROOT ROT

VISION

Where root rot is eliminating the forest canopy, establish a new forest canopy as soon as possible.

GUIDELINES

- As part of timber sales, harvest root-rot overstory mortality.
- Following harvest, plant resistant and immune tree species.

IMPLEMENTATION

MANAGEMENT RESOURCES

RESPONSIBILITIES

Implementation of this Forest Management Plan is primarily the responsibility of the JBLM Forestry Branch, which is part of the Environmental Division in the Directorate of Public Works (DPW). DPW is a component of the Joint Base Garrison, an organization of government employees, contractors, and military personnel which is responsible for managing the developed areas of JBLM and the natural resources in the undeveloped training lands. Management of wildlife and cultural resources on JBLM are the responsibility of, respectively, the Fish and Wildlife Program and the Cultural Resources Program in the Environmental Division, PW.

The overall manager of JBLM's training lands is the Range Support Division in the Directorate of Plans, Training, Mobilization, and Security. Range Support is responsible for construction and maintenance of military training facilities, scheduling of military training and other uses of training lands, and management of Controlled Use Areas. All major Forestry projects, such as timber sales and contract tree planting, must be coordinated with Range Support, as must all access to impact areas or to training areas when they are designated for sole use. The ITAM program monitors the ecological health of the training lands, repairs training-related resource damage, and educates soldiers and their leaders about environmental requirements.

The Seattle District of the USACE has an office on JBLM. Forestry decides where and how much timber will be harvested, then turns over the requisite information to the USACE. The USACE prepares timber-sale contracts, advertises each sale for competitive bid, collects funds, and oversees contract administration. They also run the JBLM firewood program.

FOREST MANAGEMENT FUNDING

Department of Defense (DoD) forestry programs are "reimbursable." In other words, they borrow from appropriated funds to cover their expenses, then "pay back" the US Treasury out of the proceeds of forest product sales. Gross income is deposited in a national DoD Forestry Reserve Account. Each year, the JBLM Forestry Branch requests its budget from the Reserve Account, as does the Seattle Office of the USACEs. After deducting expenses, 40% of the net income goes as payments to the counties where the timber is cut (at JBLM, Pierce and Thurston counties) to support schools and roads (Table 5). The balance remains in the Reserve Account. Once each fiscal year, DoD forestry programs compete for the excess funds in the account to fund special projects that support natural resources management.

During the past five years, JBLM timber sale revenue has fluctuated substantially (Table 5). Factors affecting annual gross revenue include *stumpage* prices, the state of the regional and national economy, and whether or not building construction and military training require extra sales that are not part of normal Forestry planning.

FORESTRY BRANCH ORGANIZATION

The authorized Forestry Branch footprint currently has seven full-time government employees and fourteen part-time, seasonal government employees. Five professional staff (three foresters, one ecologist, one fire management specialist) oversee the major Forestry program areas:

- Installation Forester – Responsible for supervising Forestry Branch employees, program planning and budgeting, and Forest Stewardship Council certification.
- Timber Sales Forester – Responsible for planning, laying out, cruising, and marking timber sales.
- Stand Development Forester – Responsible for post-timber harvest site preparation (including use of herbicides), tree planting, seedling survival/growth surveys, and precommercial thinning.
- Fire Management Specialist – Responsible for fire crew training, modeling fire risk, fire prevention activities, wildfire suppression, prescribed burning (in coordination with JBLM Fish & Wildlife), and fire reporting.
- Ecology – Responsible for ensuring forestry operations conform to this management plan, ecological inventory/monitoring, ecological restoration, and forestry research.

The professional staff is assisted by three forestry technicians and one contract employee. The seasonal employees are trained to suppress wildfires and carry out prescribed burns, and to assist with timber sales and other forestry activities. The contractor manages Forestry databases, runs the Forest Projection Software, and analyzes remote-sensing data.

Support for forest management (e.g., access road grading, blocking skid trails, fireline creation) is provided by the Roads and Grounds section of DPW, which employs equipment operators.

PLANNING

This Forest Management Plan is complemented by a Forestry Implementation Guide that provides day-to-day, "nuts and bolts" guidance for Forestry staff implementing goals, objectives, and management actions. The guidance changes frequently in response to changes in laws, regulations, and policies, experience with on-the-ground management actions, and the results of relevant research. Thus, it is a "living document" that evolves over time under the limits set by the Forest Management Plan.

Forestry professional staff develops proposed, on-the-ground projects within each program area. Sometimes multiple program managers collaborate with each other, or with other organizations on JBLM (especially the Fish & Wildlife Branch) to design multidisciplinary projects for particular areas of land or particular natural resource management issues.

During project planning, informal consultation occurs between Forestry, other DPW programs (especially Fish & Wildlife and Cultural Resources), and Range Support. Formal consultation may also occur with other federal or state agencies, e.g., if projects may have effects on rare species/ecosystems or cultural/tribal resources.

All proposed projects go through a deconfliction process overseen by the National Environmental Policy Act (NEPA) program in the Environmental Division, DPW. Deconfliction meetings, held approximately monthly, bring together representatives from a wide variety of JBLM organizations to review projects while still in the planning stages to identify concerns and opportunities before final decisions are made. For example, each fiscal year's package of proposed timber sales goes through deconfliction.

FOREST MANAGEMENT

FOREST CERTIFICATION

The Forestry Branch will carry out the management actions described under:

- Goal 9, "Maintain third-party certification as a sustainable forest."

FORESTS WITH HIGH CONSERVATION VALUE

An analysis of JBLM and regional forests was carried out in 2012 to identify areas with high conservation value or that are representative of undisturbed or rare forest types (Foster 2012). This was in response to a Forest Stewardship Council certification requirement that forested areas be inventoried that:

- Have high conservation value.
- Possess rare, threatened, and endangered (RTE) species and ecosystems.
- Provide protection from erosion and flooding.
- Represent undisturbed reference conditions.
- Represent regionally rare forest types.

These areas must be managed in a manner that will protect their unique values.

High Conservation Value Forests

High Conservation Value Forests (HCVFs) on JBLM are (Table 12):

- Old-growth stands.
- Stands with scattered legacy trees.
- Oak- and pine-dominated stands.
- Concentrations of minor tree species.
- Stands with unusual mixtures of tree species.
- Areas with rare plants.
- Areas with steep, erodible soils.
- Floodplains (wetlands and riparian zones are separately protected by buffers).

Representative Sample Areas

Representative Sample Areas (RSAs) on JBLM are:

- Reference stands that have never received management.
- Quaking aspen clones.
- Stands dominated by Pacific madrone or with large western redcedar.

Table 12 shows the acreages and management restrictions for HCVFs and RSAs and Figure 14 shows their locations. Wildfire control is permitted in all areas. The management restrictions are intended to conserve the values for which each HCVF and RSA has been designated. Many of the protected areas are located in impact areas, providing them with a high degree of protection from disturbance.

It should be noted that HCVFs and RSAs are Forestry Branch designations. Only Controlled Use Areas (Figure 3) are recognized by military trainers and given specific protections in JBLM

regulations, although in many cases HCVFs/RSAs and CUAs overlap. Occasionally, the needs of training may result in management actions occurring within HCVFs and RSAs that are contrary to Forestry Branch management designations.

FOREST VEGETATION

Oak- and Pine-Dominated Communities

The Forestry and Fish and Wildlife Branches will continue ecological restoration of oak- and pine-dominated stands toward conditions more similar to those found prior to Euro-American settlement. This will include actions such as large Douglas-fir removal (as part of timber sales), precommercial removal of dense young conifer clumps and thinning of dense oak and pine clumps, brush removal, prescribed fire, and planting of oak and pine.

Rare Plants

Forest management activities within the area of influence for wetlands containing water howellia will be analyzed by the JBLM Fish and Wildlife Branch for possible impacts, in accordance with the ESMP for water howellia (US Army 2012a), a component of JBLM's INRMP. The *area of influence* is a 165-foot buffer from the edge of the wetland, the same as the military buffer, and 10 feet less than the standard forest management buffer (175 ft). Actions with the potential to disturb water howellia populations will be avoided.

No ground-disturbing forest management will occur within areas containing populations of small-flowered trillium. These areas are protected as RSAs.

Invasive Plants

Current programs to control Scotch broom on JBLM will continue. In oak- and pine-dominated stands, the Forestry and Fish & Wildlife Branches will remove broom (mowing, handcutting, spraying, prescribed burning), partly in-house but mostly through contracts. The Forestry Branch will control broom in forest plantations and logging landings. The main control method is herbicides, shown by research to be the most effective tool. The Forestry Branch has also initiated a control program for English ivy, English holly, common periwinkle, and yellow archangel in forested areas, using a combination of mechanical and chemical control.

FOREST FISH AND WILDLIFE

Western Gray Squirrel

Management of western gray squirrels on JBLM is laid out in the ESMP for the Western Gray Squirrel (US Army 2012b), a component of JBLM's INRMP. According to this ESMP, existing and potential squirrel habitat within planned timber sales or ecological restoration projects will be surveyed by the Fish and Wildlife Branch for nests and core habitat. Subsequently, the Forestry Branch will coordinate with the Fish & Wildlife Branch on spatial scale and management activity timing issues that might impact squirrel populations. If necessary, additional trees will be marked for harvest and/or squirrel core areas excluded from harvest.

Timber harvest is prohibited within identified squirrel habitat in Training Areas 7N, 7S, 8, 9, 10, and 12 (the heart of the species' distribution on JBLM) during the nesting season (March 1 to August 31) unless an exception is granted by Fish & Wildlife. Although the squirrel population

is continuing to expand across JBLM, the seasonal prohibition will not apply outside the core training areas.

Northern Spotted Owl

The Forestry Branch will carry out the management actions described under:

- Goal 10, "Manage for long-term creation of northern spotted owl habitat."

A Revised Recovery Plan for the Northern Spotted Owl was issued in 2011 (US Fish and Wildlife Service 2011). In early 2012, JBLM was notified by the USFWS that we were proposed for re-designation as critical habitat under the Proposed Rule for the Revised Recovery Plan (US Fish and Wildlife Service 2012c). However, in December 2012 JBLM secured an exemption from this designation under the 2004 National Defense Authorization Act by preparing an ESMP for Northern Spotted Owl Critical Habitat (US Army 2012f), that outlined how the base would manage forests to create late-successional habitat, as part of our updated INRMP that contains provisions for creating and protecting owl habitat. The ESMP requires JBLM to:

- Inventory existing owl nesting, roosting, foraging, and dispersal habitat on JBLM.
- Carry out forest practices in the Owl Habitat Focus Area (Figure 7) that will accelerate the development of late-successional forest structures favored by owls and their prey.
- Monitor the progress over time of JBLM's forest stands toward owl habitat.

The Forestry Branch will use LiDAR analysis to identify forest stands across JBLM that currently fit the definitions of owl nesting/roosting, foraging, and dispersal habitat. The criteria for these definitions are the Primary Constituent Elements (PCEs) for owl habitat described in US Fish and Wildlife Service (2012c).

As described in Chapter Two, variable-density thinning (VDT) is the primary forest management tool for accelerating the development of late-successional forest structures such as large old trees, large snags and logs, and multiple canopy layers. VDT and other management actions will be taken in all stands identified as potential nesting/roosting habitat within the Focus Area.

The stand exam program will be expanded to include extra stands in the Focus Area to assist in monitoring temporal changes in stand structure towards owl-habitat PCEs.

Other Birds

The Forestry Branch will not schedule timber sales within bald eagle nest and roost sites (year-round) and winter-use areas (seasonal) (circular areas in Figure 3). This will assure that we do not violate the Bald and Golden Eagle Protection Act that prohibits take of bald eagles.

To avoid take under the Migratory Bird Treaty Act, the JBLM Fish & Wildlife Branch will carry out conservation measures to protect migratory bird habitat, as described in the INRMP. Forest management actions (e.g., timber sales) may be part of these measures.

Fish

In accordance with the ESMP for chinook salmon, steelhead, and bull trout (US Army 2012c), forest management activities within the area of influence (watershed) of lakes, rivers, and streams will be analyzed for potential impacts on chinook salmon, steelhead, and bull trout by the JBLM Fish & Wildlife Branch. Activities that could potentially impact these fish populations

or their potential habitat will be avoided. The presence of wetland/riparian buffers will provide protection to other sensitive, but non-listed fish species, e.g., coastal cutthroat trout, lampreys.

Since no timber harvest is permitted on the floodplains and adjacent steep bluffs along the Nisqually River and Muck Creek (Figure 14), forest management activities with impacts on fish and fish habitat are unlikely to occur.

Amphibians

The single population of Oregon spotted frog in Dailman Lake in the RTA is protected by existing military and forestry wetland buffers. No additional impacts on forest management are expected during implementation of the ESMP for the Oregon Spotted Frog (US Army 2012d).

Western toads migrate out of several RTA lakes between mid-March and the end of September. If migration is observed during logging, Forestry consults with JBLM Fish & Wildlife about how to reduce impacts to Western toads; this may include temporarily or seasonally curtailing logging.

WETLANDS

The Forestry Branch will carry out the management actions described under:

- Goal 3, "Manage to maintain site productivity."

In addition to the 165-foot military buffers (Figure 3), the Forestry Branch recognizes two types of buffers adjacent to all wetlands, streams, and lakes. These buffers were developed in 2010 with input from the Fish & Wildlife Branch. Buffers protect water quality and temperature, and prevent incompatible activities on compacted soils. Inner buffers are 75 feet in width from the ordinary high water mark, and have the following management restrictions:

- Single-tree selection harvest only, and only as part of ecological restoration.
- No use of heavy equipment, except where there is no practical alternative.
- No new roads or skid trails. Close roads that do not impact military training.

Outer buffers are 100 feet in width from the outer edge of inner buffers to 175 feet from the ordinary high water mark, and have the following management restrictions:

- Single-tree or group selection tree harvest only, and only as part of ecological restoration.
- Minimal use of heavy equipment.

CULTURAL RESOURCES

The Forestry Branch will carry out the management actions described under:

- Goal 7, "Manage to protect cultural resources, including traditional uses by Native Americans."

The Forestry Branch will continue to consult with the JBLM Cultural Resources Program on all forest management activities. Known cultural sites will remain off-limits to timber harvest and other ground-disturbing activities. If during the implementation of management activities, a previously unknown cultural site is discovered, all activity will stop until the Cultural Resources Program can survey the site and decide when and how activities may proceed.

CHEMICAL USE

Two factors have recently contributed to increased herbicide use by the JBLM Forestry Branch. The first factor is the need to control Scotch broom in areas being reforested, logging landings, and pine/oak stands receiving ecological restoration. Forestry-supported research has demonstrated that use of herbicides is the most effective way to control broom. The second factor is that the Forestry Branch is initiating a long-term program to control other invasive plants (ivy, holly, periwinkle) in forested areas. Effective control of each of these species necessitates the use of herbicide use in addition to control by mechanical means or prescribed fire.

In accordance with the JBLM Integrated Pest Management Plan (US Army 2010), all herbicide application will be overseen by a person with a DoD- or State-certified pesticide applicator license. Herbicide application in the training areas will occur only with Range Support permission. No herbicides that are banned by FSC (Forest Stewardship Council 2005) will be used within the FSC-certified area (Figure 2).

FOREST RESOURCES

Military Use

The Forestry Branch will carry out the management actions described under:

- Goal 1, "Manage for a variety of forest stands to support military training."

To the extent possible, we will coordinate with military trainers to locate proposed training and construction projects to locations that will minimize their impact on forest resources.

Timber Sales

The Forestry Branch will carry out the management actions described under:

- Goal 2, "Manage for retention of native biodiversity, including rare or unique flora and fauna."
- Goal 3, "Manage to maintain site productivity."
- Goal 8, "Manage to provide public benefits."

In collaboration with the Fish & Wildlife Branch, the Forestry Branch will continue the 18-year-old program of ecological restoration in stands with a major component of oak and/or pine. Forest management will continue to use practices that minimize soil erosion/compaction and sediment delivery to wetlands. The timber-sale and firewood programs will continue, as will tribal access to traditional cultural use of forest resources.

Stand Development

The Forestry Branch will continue to reforest openings created by timber sales or laminated root rot mortality, using resistant and immune species. When needed to reduce dense native brush or control Scotch broom, site preparation activities will be carried out. Precommercial thinning will be carried out in young, dense stands.

Fire Management

The Forestry Branch will carry out the management actions described under:

- Goal 4, "Manage to reduce the risk of stand-replacement wildfire."

Control of wildfire will be conducted by the Forestry Branch, in cooperation with the JBLM Emergency Services Directorate (i.e., fire department). The Fish & Wildlife Program will have primary responsibility for the prescribed burning program, assisted by Forestry.

Disturbance

The Forestry Branch will carry out the management actions described under:

- Goal 5, "Manage to reduce the risk of insect and disease epidemics."
- Goal 6, "Manage to minimize the impacts of non-native species."

We will expand the scope of our current Scotch broom control efforts to include not just plantations and oak/pine stands, but logging landings. As described under Chemical Use, we anticipate increased use of herbicides for control of Scotch broom and other invasive, non-native plants.

Logging Machinery

JBLM does not limit the types or sizes of harvesting machinery, but does place limits on where and when specific types of equipment can be used. In general, slopes of 30% and 50% are the standard operating limit for wheeled and tracked equipment, respectively. Ground-based systems are also not used on slopes where, in the opinion of the government, their operation would cause excessive erosion, stream *sedimentation*, actual or potential material damage to a public resource. On slopes over 50%, cable-based logging systems may be used by exception.

Ground-based equipment is not used on exposed, erodible soils or on saturated soils if sediment delivery is likely to disturb a wetland, stream, or lake. When soil moisture is high and unrestricted operation of ground-based equipment could result in unreasonable soil compaction, operations are restricted to methods that minimize soil compaction (e.g., tracked rather than rubber-tired skidders). Harvesting may also be postponed until site conditions improve such that yarding may proceed without causing unreasonable soil compaction.

Inventory and Monitoring

The Forestry Branch conducts monitoring of forest resources on JBLM (see Chapter Two). These activities are required both by Army Regulation 200-1 and by JBLM's FSC certification. The Fish & Wildlife Branch is responsible for monitoring of fish, wildlife, and wetlands, while the Cultural Resources Program carries out monitoring for cultural resources.

All quantitative monitoring that is based on sampling (i.e., less than 100% of the resource surveyed) will follow standard statistical guidelines for replication and comparisons between locations and different sampling times (e.g., Foster 2001).

Forest Products

The USACE maintains records of commercial timber sales. The amount of wood harvested, by species and category, is usually determined by *scaling* of logging-truck loads. The two categories are *sawlogs* (of suitable size and quality to cut into lumber or mill as *veneer*; includes utility poles) and *utility wood* (all other merchantable wood, including pulp, firewood, and posts). Occasionally, sales are sold "*lump sum*," meaning that only the total volume of wood removed is known, based on pre-sale cruises.

Precommercial sales occur only occasionally. Pre-sale *cruises* estimate the volume of wood cut and either removed from the site by the contractor or left in place. The USACE keeps records of the volume of firewood (cords) sold both commercially and for personal use. s sales, when they occur, are sold by the ton, based on estimates of pile and slash volume.

Harvest of non-traditional forest products (salal, ferns, mushrooms, etc.) is allowed for tribal use only. No records are kept.

Forest Inventory

Once the current stand exam is completed, we will initialize a computer model known as the Forest Projection and Planning System (FPS). FPS is a spatially explicit forest inventory, growth, and planning model that uses an "in-place" inventory (i.e., polygon-based in GIS) and a calibrated growth model. The polygons will be the new, ecologically based stands GIS layer. With this software, we will be able to track inventory, harvest, and mortality across any given portion of JBLM. The model will also help us choose stands each year for management treatment and re-inventory.

FPS is designed to provide good estimates on a 15-year cycle of stand exam re-measurements, i.e., about 5-7% of stands per year. JBLM's stand exam program, which replaces the now-discontinued ISI, began three years ago. Stand exams are conducted following each timber sale, and in areas not available for harvest, on a cycle of 15 years or less. Stand exam results will allow us to look for differences in attributes between forest types (especially ecological forest types) at any given sampling time, as well as changes between sampling times. These changes will be compared to control stands, i.e., unmanaged stands protected as Representative Sample Areas.

Northern Spotted Owl Habitat

JBLM recently finished an inventory of current owl habitat across the installation. We will use expanded stand exams within the Owl Focus Area (Figure 7) to monitor development of owl habitat over time.

Oak, Pine, and Old-Growth Habitat

Current monitoring for the ecological condition of oak- and pine-dominated stands, and of old-growth stands, will continue. In addition, permanent plots will be installed in those stands identified as having scattered legacy trees in the Central Impact Area (Figure 14).

Forest Disturbance

When potential timber sales are being laid out, forestry technicians will evaluate all areas of recently dead and dying trees to determine presence of root rot or other potential fungal *pathogens*. All such areas will be mapped in GPS.

The effects of timber sale operations, including access roads, on soil erosion and compaction are visually monitored by the USACE as part of contract compliance. As discussed in Chapter Two, detailed monitoring of soil damage is unnecessary on JBLM because of our flat terrain and very rocky soils that are highly resistant to compaction and erosion.

Timber theft is monitored as it is found. The locations of illegally cut trees are recorded with GPS and the stump diameters used to estimate the wood volume removed. These data are forwarded to a Public Works employee whose job is to monitor illegal use of JBLM training lands, and to Military or DoD police because timber theft is a criminal activity.

Forest Flora and Fauna

Inventory and monitoring of Federal- and state-listed species and candidates for listing is the responsibility of the JBLM Fish & Wildlife Branch. This monitoring is described in the INRMP. In addition, the Forestry Branch pays for the Fish & Wildlife Program to survey upcoming timber sales for raptor nests.

In 2017, a contractor will do field sampling within several of JBLM's soil types to try to elucidate relationships between soils, vegetation, and topography. If successful, the results will improve mapping of the three major forest ecotypes (historic moist, historic dry, prairie colonization), and will allow mapping of the component soil series with soil series complexes (e.g., McChord-Everett).

Economic and Social Impacts of Forest Management

Currently, the annual timber sales preview is sent to the three tribes with treaty rights on JBLM for their input. In addition, the JBLM Cultural Resources Program evaluates all proposed Forestry activities for potential impacts on cultural sites. If any of these sites are significant to tribes, the Cultural Resources Program interfaces with the tribes to resolve them.

Periodically, the Forestry Branch will conduct a comprehensive social/economic survey that includes responses of all categories of stakeholders (i.e., contractors, JBLM organizations, soldiers and their families, tribes, researchers) to our various forest management activities.

Costs and Revenues of Forest Management

The Forestry Branch and the USACE keep track of annual budgets from the Army and income from forest products sales. We are not required by law or policy to make a profit or even break even. However, JBLM consistently has a gross profit of more than $1 million per year.

Sustained Yield

Because of multiple clearcuts in some training areas during the 2000's decade to control laminated root rot or meet military training requirements, we need to assure that sustained yield is not exceeded in any given training area or for any particular forest type on JBLM. Once the FPS model is initialized, we will be able to track inventory, growth, and mortality, and calculate

net forest growth across any given portion of JBLM. Comparison of net growth with timber harvest will allow us to assure that sustained yield is never exceeded in any portion of JBLM during any 10-year period.

MANAGEMENT ACTIONS

Table 16 shows the potential management actions that the Forestry Branch will carry out to implement the Forest Management Plan.

Table 16. Potential management actions under the JBLM Forest Management Plan.

Management Action	**Number**[1] **/ Acres**	**Frequency**[2]
Timber sales	15-20 / 1,500-2,200	
variable-density thinning	5-10 / 750-1,100	annual
VDT with gaps	5-10 / 750-1,100	annual
clearcuts	1 / 1-50+	irregular[3]
alder removal	1 / <100	five years
salvage	1 / variable	irregular[4]
construction[5]	2-10 / variable	annual
Road maintenance[6]	15-20 / 2-5 miles	
Stand development		
site preparation	10-15 / 75-150	annual
tree planting	10-15 / 75-150	annual
precommercial thinning	1 / 20-100	five years
Brush control[7]	1-3 / 0-100	
Fire		
prescribed burning[8]	20-50 / 1,000-2,500[9]	annual
wildfires	15-50 / 300-4,000[10]	annual
fuels reduction[11]	variable	annual
Ecological restoration[12]	3-10 / 20-100	two years
Invasive plant control		
Scotch broom[13]	2-5 /10-100	annual
ivy, holly, periwinkle[14]	2-5 / 10-50	annual[15]
Cultural		
archaeological surveys	2-5 / 100-500[16]	annual
tribal use of forest products	as requested	annual
Inventory/monitoring		
stand exam	– /15,000	2014[17]
intensive stand inventory	12-15 / 1,000-1,400	ten years[18]
regeneration surveys	10-15 / 75-150	annual
disease surveys[19]	15-20 / –	
specialized monitoring[20]	1 / –	ten years
Wildlife habitat manipulation		
western gray squirrel[21]	2 / 10-100	two years
northern spotted owl	1-2 / 50-200	annual

FSC certification		
annual audit	n/a	annual
recertification audit	n/a	five years
Forest Plan revision	n/a	five years

[1]Number of separate activities or locations. [2]Average frequency, unless otherwise indicated [3]Primarily in response to military requirements. [4]Following unpredictable wind/ice storms. [5]Tree removal to accommodate construction projects, mostly in cantonmen.t [6]Includes rocking carried out by loggers and grading/brush control carried out by Forestry. [7]As needed, in areas where dense brush repeatedly impedes dismounted training; control is mechanical. [8]Carried out by JBLM Fish & Wildlife Branch, primarily to control Scotch broom. [9]Affected by weather and fire bans. [10]Most of this acreage is fires within the Artillery Impact Area, which are allowed to burn to the perimeter. [11]Occurs as part of timber sales, ecological restoration, brush control, and prescribed burning. [12]Varying proportions of commercial/ precommercial thinning, Scotch broom control, prescribed burning, tree planting. [13]Mechanical or chemical; includes control in plantations and logging landings, and as part of ecological restoration. [14]Chemical control . [15]Frequency will decline following initial control in each area. [16]Occurs on that portion of timber sales not previously surveyed. [17]One-time occurrence. [18]Requires five years to complete. [19]Conducted as part of timber sale layout; occasional special surveys may occur. [20]Oak woodlands, pine stands, owl habitat, old-growth stands. [21]Only that portion carried out as part of timber sale prescriptions or Forestry-funded ecological restoration.

CLIMATE CHANGE

Computer models of climate generally agree that the Pacific Northwest west of the Cascade Mountains will become, over the next half century, gradually warmer and wetter, with most of the precipitation increase in winter (JIASO Climate Impacts Group 2007). Wetter winters will likely mean more flooding of rivers and more landslides on steep terrain. The region's warm, dry summers may see slight increases in rainfall, but the gains in rainfall will be more than offset by losses due to increases in *evaporation* and *transpiration*, so soils may become drier by late summer/early fall.

One consequence of these trends will be increased frequency and severity of wildfires, the flame and smoke contributing both gaseous and particulate carbon to the atmosphere. However, the likely increased growth of forests will sequester more carbon and live and dead biomass. How these two source/sinks compare quantitatively is the subject of much scientific research, without consensus being achieved yet.

For the coastal variety of Douglas-fir, *radial growth* is sensitive to summer precipitation and the temperature of the preceding winter, suggesting that growth is limited by drought and that winter photosynthesis contributes to growth. Modeling of this species' growth response to climate change has shown either no consistent positive or negative outcome (Chen et al. 2010) or a substantial decline in the geographic area with a suitable climate (Littell et al. 2010). However, the geographic range of Oregon white oak is expected to expand substantially because this species is very drought-tolerant (Aubry et al. 2011, Pellatt et al. 2012). A range expansion of ponderosa pine is also possible (Aubry et al. 2011), but long-distance seed transport will be necessary from the isolated JBLM population. Range expansion and increased growth are predicted for red alder (Cortini et al. 2012).

Another potential effect of climate change is increased frequency and intensity of fungal pathogen epidemics, particularly if the change is to warmer and drier (Kliejunas 2011). This could produce both increased tree mortality and a lack of regeneration in conifer-dominated forests.

JBLM is too small to consider use of *assisted migration* (Aubry et al. 2011, Williams and Dumroese 2013) of tree species within the installation. There are, however, two actions the Forestry Branch could take now to increase the *resilience* of our forests in the face of climate change:

- Western white pine is being considered for artificial regeneration of root rot pockets on JBLM, especially in historic dry forests, because it is resistant to root rot and adapted to well-drained soils. However, this species is susceptible to blister rust (*Cronartium ribicola*), so it is important that seed sources are screened to be rust-resistant.
- Non-native ponderosa pine is present on JBLM in several plantations. These pines are all of eastern Washington *provenance*. It is desirable to remove non-native pine because it is probably less well-adapted to western Washington's climate, so *gene exchange* (via pollen) with the native pines could exacerbate the effects of climate change on the latter.

PLAN REVISION

This Forest Management Plan will receive annual reviews, at which time minor revisions may be implemented. Major revision of this plan will happen under the following circumstances:

- A major change in on-the-ground conditions.
- A major change in law or policy affecting Army forest management.
- A major revision of the JBLM Integrated Natural Resources Management Plan

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GLOSSARY

Active Management – Deliberate human management, as opposed to passive (hands-off) management.

Age Class – An interval into which the age range of trees or forest stands is divided for classification or use (e.g., 0–10 years, 10–20 years, etc.).

Alluvial – Composed of materials deposited by rivers, floods, etc.

Aquifer – A water-bearing stratum of permeable rock, sand, or gravel.

Confined – An impermeable dirt/rock layer prevents water from seeping into the aquifer from the ground surface located directly above.

Unconfined –Water can seep from the ground surface directly into the aquifer.

Assisted Migration - The act of deliberately moving plants or animals to a different habitat.

Backfire – A fire set intentionally to arrest the progress of an approaching fire by creating a burned area in its path, thus depriving the fire of fuel.

Basal Area – The cross-sectional area of the trunk 4 1/2 feet above the ground; (per acre) the sum of the basal areas of the trees on an acre; used as a measure of forest density

Biodiversity – The diversity of plants, animals, and other living organisms in all their forms and levels of organization, including the biological diversity of genes, species, and ecosystems.

Biomass – Leftover slash and non-merchantable material from a timber sale which can be chipped and burned in power plants.

Board Foot – A unit of volume for timber equal to 144 cubic inches, notionally twelve inches by twelve inches by one inch.

Bulb – A short stem with fleshy leaves or leaf bases that function as food storage organs during dormancy.

Butt – The enlarged base of a tree stem.

Canopy Cover – The more or less continuous cover formed by tree crowns in a forest. 100% cover means that tree crowns (often overlapping) cover all of the underlying ground

Canopy Gap – A distinguishable hole in a forest canopy.

Canopy Lift – The distance between the top of the shrub layer and the bottom of the forest canopy.

Chlorinated Hydrocarbons – Toxic organic compounds, found in pesticides (including now-banned DDT) that are neurotoxic in animals and, because they are soluble in fat, bioaccumulate (concentrate) up food chains.

Clearcut – The harvest of all the trees in an area.

Clonal – Reproducing asexually (vegetatively).

Coarse Woody Debris – Sound or rotting logs, stumps, or large branches that have fallen or been cut and left in the woods, or trees and branches that have died but remain standing or leaning.

Cobble – A rock fragment larger than a pebble but smaller than a boulder.

Commercial – Provides income to a forest-land owner.

Compaction – When soil particles are pressed together, reducing pore space between them.

Conservation Reliant – Species that require human intervention to avoid extinction.

Core Areas – For wildlife, key habitat essential to survival, usually areas where breeding occurs.

Critical Habitat – Habitat necessary to the survival of species listed under the Endangered Species Act.

Crown – The uppermost branches and foliage of a tree.

Crown Fire – A forest fire that spreads from treetop to treetop.

Cruise – A *sample* measurement of a stand used to estimate the amount of standing timber that it contains.
Culmination of Mean Annual Increment – The highest average annual increase in volume growth across all trees in a forest stand.
Deconfliction – The act of reducing conflicts between competing interests.
Defect – A physical deformity in a tree stem that reduces its commercial value.
Densic – A soil layer dense enough to restrict root and water penetration.
Density – The number of trees per unit area.
Depauperate – Lacking in variety of species.
Desired Future Condition – A concise statement that describes intended results or desired conditions.
Diameter at Breast Height (dbh) – A standard measurement of a tree's diameter, usually taken at 4 1/2 feet above the ground
Dispersal – The movement or transport of seeds away from the parent plant.
Drift – Any material transported and deposited by a glacier or glacial meltwater.
Drumlin – An elongated, teardrop-shaped hill formed by glacial ice acting on underlying unconsolidated till or ground moraine.
Ecological Restoration – The practice of renewing and restoring degraded, damaged, or destroyed ecosystems and habitats in the environment by active human intervention.
Ecosystem – All of the living things in a given area, interacting with each other and with their non-living environment.
Ecosystem Management – A process that aims to conserve major ecological services and restore natural resources while meeting the socioeconomic, political and cultural and needs of current and future generations.
Ecotone – A transition area between two distinct, but adjoining, communities or ecosystems.
Ecotype – In forestry, a distinct type (in terms of structure, species composition, and/or origin) of forest.
Ectomycorrhizae – Fungi that form a symbiotic relationship with plant roots; they cover the outer surface of fine roots and extend filaments into the surrounding soil. Multiple species are associated with Douglas-fir.
Endemic – A plant or animal restricted to a certain geographic area or vegetation type.
Erosion – A naturally-occurring process whereby the top layer of the soil is worn away by water and wind.
Esker – A long, narrow, winding ridge of sand and gravel deposited by a meltwater beneath a glacier.
Evaporation – The process by which liquid water on the ground or plant surfaces is converted to water vapor.
Experimental Design − The process of planning a scientific study or inventory/monitoring to meet specified objectives, e.g., using the right type of data, having a sufficient sample size to answer the questions of interest.
Extirpated – Extinct in a local area, but not the species as a whole.
Feller-Buncher – A tracked machine with an attachment that can rapidly cut and gather several trees before felling them.
Floristics – The study of the distribution and relationships of plant species across geographic areas.

Fluvial Terrace – Remnants of the former floodplain of a river or stream channel, created by downcutting of the river or stream.
Foraging – The act of animals acquiring food.
Forb – An herbaceous (non-woody) flowering plant that is not a graminoid.
Forested Wetland – An area characterized by woody vegetation taller than 20 feet where soil is at least periodically saturated or covered by water.
Forwarder – A wheeled or tracked machine that carries logs, clear from the ground, from the stump to a landing.
Free to Grow – Planted trees that have reached a height where they can no longer be outcompeted by undesired plants.
Gene Exchange – The transfer of genes between organisms. In plants, this is usually via pollen.
Genotype – The genetic makeup of an individual organism.
Germinant – A tree seedling that has just emerged from a seed and opened its cotyledons (first leaves).
GIS – Geographic Information System: a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial and geographic data.
Graminoid – A grass or grasslike plant.
Heavy Equipment – Heavy-duty vehicles specially designed for executing construction tasks, especially earthwork.
Height:Diameter Ratio – The ratio of the height of a tree to its diameter at breast height.
Hiding Cover – Natural or artificial objects that conceal military personnel, vehicles, and equipment.
Holocene –The geological epoch that began after the Pleistocene about 12,000 years before present.
Horizontal Diversity – The degree of spatial variation in stem density, tree diameter, and species composition across a forest stand.
Humvee – High Mobility Multipurpose Wheeled Vehicle (HMMWV),a jeep-like vehicle widely used by the Army.
Invasive – A plant species which grows aggressively, spreads, and displaces other plant species.
Inventory – An accounting of trees and their related characteristics of interest over a well-defined land area.
Lacustrine – Large, open, fresh-water-dominated wetlands (e.g., lakes).
Landing – A cleared area within a timber sale where harvested logs are processed, piled, and loaded for transport to a sawmill or other wood-processing facility.
Late-Successional – Mature forests that are starting to acquire old-growth characteristics.
Legacy – Left over from a previous forest stand, e.g., large trees, snags, and logs.
Leguminous – Belonging to the pea family of plants.
LiDAR – Light Detection and Ranging: A remote-sensing technique that use laser pulses of near-infrared light to map the three-dimensional structure of vegetation.
Listed – Legally declared to be threatened or endangered under the federal Endangered Species Act or equivalent legislation at the State level.
Litterfall – Plant material, such as leaves, bark, needles, and twigs, that has fallen to the ground.
Loader − A tracked machine used to load and unload timber from logging trucks and storage piles.
Lump Sum – The outright sale of standing timber for a fixed dollar amount agreed upon in advance.
Maneuver – A planned and regulated movement of troops and/or military vehicles.

Dismounted – Soldiers are walking.
Mounted – Soldiers are riding in vehicles.

Mast – Nuts and seeds, such as berries, acorns, pine cones, of trees that serve as food for wildlife.

Meander – A winding curve or bend of a river.

Mensuration – The measurement of forest attributes such as height, diameter, and volume.

Merchantable – Wood that can be sold for a profit.

Mima Mound – Low, circular to oval, domelike natural mounds composed of loose, unstratified gravelly sediment overlain by a thick A horizon. Cause is unknown.

Monitoring – Observe and check the progress or quality of forest attributes over a period of time.

Monoculture – The cultivation of a single species of tree in a given area.

Mop-Up – After a fire has been controlled, all actions required to make the fire safe prior to being called out (e.g., extinguishing still-burning fuels, felling snags, etc.

Moraine – An accumulation of earth and rock carried and finally deposited by a glacier.
Terminal – Deposited at the terminus of a glacier at its furthest extent.
Recessional – Deposited at the terminus of a glacier during a halt in its melting back.

Mortality – Death of trees.

Mycelia - The vegetative part of a fungus, consisting of a mass of branching, thread-like hyphae (fungal filaments).

Natural Seeding – Seed deposited on the ground by existing overstory trees.

Net Growth – The difference between total tree growth and losses due to mortality and harvest.

Net Primary Productivity – The difference between gross primary productivity (total production of new organic matter) and losses due to mortality and removal.

Non-Commercial – Not available for commercial tree harvest due to low economic value or other reasons.

Noxious Weed – An invasive plant species, usually non-native, that is toxic to animals.

Old Growth – Forests that is greater than 200 years of age, substantially altered by humans, and possessing large living trees, a multi-layered canopy, and substantial accumulations of coarse woody debris, including large snags and logs.

Organic Matter – Carbon compounds formed by organisms, whether still living or dead.

Outwash – The material, chiefly sand or gravel, deposited by meltwater streams in front of a glacier.

Overstory - the level of forest canopy that includes the crowns of dominant, codominant, and intermediate trees

Overtopping – When the crowns of faster-growing conifers extend above and over the crowns of slower-growing oaks, the latter are suppressed.

Palustrine – Wetlands characterized by a lack of flowing water and the presence of trees, shrubs, and emergent (rooted below water but growing above surface) vegetation.

Pathogen – A disease-causing organism (fungi, bacteria, viruses, etc.).

Physiognomy – The overall structure or physical appearance hat the community and its dominant species look like, their height and spacing (height and canopy cover), and shape

Plant Association – A collection of plants with ecologically similar requirements, including one or more dominant species from which the group derives a definite character.

Plantation – A new forest area established by tree planting.

Planting – The act of placing tree seedlings (artificial regeneration) in the ground.

Pleistocene - The geological epoch which lasted from about 2.6 million to 12,000 years ago, spanning the world's most recent period of repeated glaciations.

Population – All of the individuals of a particular species living in an area and capable of interbreeding.
Porosity – The amount of pore space (voids between soil particles) in a soil.
Precommercial – Forestry operations that require landowner investment, as opposed to commercial operations that provide income.
Prescription – A planned treatment of a forest site designed to change current stand structure or condition to one that meets management goals.
Burn plan – A prescription for a controlled burn.
Provenance – The population of trees growing at a particular location of origin.
Prescribed Burn – An intentionally set fire to meet forest management objectives (also called a controlled burn).
Pulpwood – Wood suitable for use in paper manufacturing.
Pyrotechnics – Materials capable of undergoing chemical reactions to produce heat, light, gas, smoke, or sound, e.g. flares, smoke and stun grenades.
Radial Growth – Annual increase in diameter of a tree.
Range Expansion – An increase in size in the geographic area occupied by a species.
Raptor – Bird of prey, such as hawk, eagle, etc.
Reference Stand – A forest stand left to grown naturally, as compared with a managed stand.
Reforestation – Natural or intentional restocking of existing forests and woodlands that have been depleted, usually by timber harvest.
Regeneration – The process by which new trees are established.
Natural– From natural sources, such as seed from existing trees or sprouting of cut trees.
Artificial – From seedlings raised in tree nurseries or seed collected from overstory trees.
Advanced – Natural regeneration established before the existing overstory is removed.
Region of Influence – The physical area that bounds the environmental, sociological, economic, or cultural feature of interest for the purpose of analysis.
Replicate – An individual item in a *sample* from a scientific experiment or inventory/monitoring. Each replicate in a sample is a repetition of an experimental or natural condition so that the variability associated with the phenomenon under study can be estimated.
Resilience – The ability of a forest ecosystem to recover from change caused by natural or human disturbance or climate change.
Rhizome – A horizontal underground stem that puts out lateral shoots and adventitious roots at intervals.
Roosting – The act of birds settling or congregatung for rest or sleep.
Rotation – The time between the establishment of a stand of trees and when that same stand is ready for a final cut.
Roundwood – Small-diameter timber used for products that don't need squaring (e.g., posts).
Runoff – The draining away of water from the surface of the land.
Salmonid – Any of fishes of the family Salmonidae, which includes salmon, trout, grayling, and whitefish.
Salvage – The removal of dead, damaged, or diseased trees to recover maximum value before they undergo decay.
Sample – A random (usually) selected set of individual items from all available items used to characterize the full set of items. Example: A stand exam measures the diameter of one out of every 20 trees in a forest stand, then uses the sample to estimate the average diameter and its variability for all the trees in a stand.

Sawlog – A log large enough (usually eight inches diameter at the small end) to be sawed economically at a sawmill.
Sawtimber – Trees from which sawlogs can be made.
Scaling – The determination of the gross and net volume of logs.
Scarification – Techniques that prepare a harvested site to be a seedbed or ready for tree planting. Typically involve debris removal and disturbance of the surface soil.
Sedimentation – The settling of particles out of surface waters to form sediments on the bottom. The source of these particles is often erosion from the surrounding landscape.
Seed Bank – The total amount of dormant seed of a plant species in the soil.
Seed Zone – An area of sufficiently uniform ecological conditions that forest stands show similar phenotypic or genetic characters.
Seibert-staked – An area with boundaries delineated by vertical PVC posts with reflective color markings at the top. These areas are off-limits to off-road maneuver, digging, and bivouacking.
Selection Harvest – The practice of harvesting trees in a way that moves a forest stand towards an uneven-aged condition.
Single-Tree – Individual trees of all size classes are harvested more or less uniformly across a forest stand. Used when all of the favored species are shade-tolerant.
Group – Patches of trees are harvested across a forest stand. Used when some of the favored species are shade-intolerant.
Shade Tolerance – How well a tree species survives and grows in the shade of other trees.
Shelterwood – The harvest of all mature trees in an area in a series of two or more cuts, leaving enough trees of other sizes to provide shade and protection for forest seedlings.
Silviculture – The practice of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values.
Site Index – A measure of the quality of a site based on the height of dominate trees at a specified age (usually 25 or 50 years), depending on the species.
Site Preparation – Treatment of an area prior to re-establishment of a forest stand, e.g., scarification, brush removal, herbicide treatment.
Size Class – An interval into which the diameter range of trees or forest stands is divided for classification or use (e.g., 0–4 inches, 4-8 inches, etc.).
Skid Trail – Temporary roads used for yarding.
Skidder – A rubber-tired machine with a cable winch or grapple used to drag logs out of the forest.
Slash – Coarse woody (stumps, leftover logs) and fine woody (branches, twigs) and non-woody (leaves, cones) debris generated by logging.
Snag – A standing dead tree.
Soil Horizon – A generally horizontal layer whose physical characteristics differ from the layers above and beneath.
Stand – A contiguous group (typically one acre or larger) of trees sufficiently uniform in composition, structure, age/size class distribution, spatial arrangement, site quality, condition, or location to distinguish it from adjacent groups.
Stand Exam – Forest inventory on a stand-by-stand basis.
Stand Replacement – Forest fires that completely burn or kill the existing forest.
Standing Stock – The total volume or weight of commercial wood in an area.
Stomata – Microscopic openings in plant leaves that can be opened or closed to regulate transpiration and photosynthesis.

Stryker – A series of 8-wheeled, lightly-armored combat vehicles equipped with various types of light weapons.
Stumpage – A price on standing timber, reckoned as a unit value per stump, board foot, or other measure.
Succession - Primary Succession – The more or less predictable process by which a biological community changes over time.
Primary - Starting on a site with no organic matter (e.g., after glaciation or severe flooding).
Secondary – Starting on a site with organic matter present (e.g., after logging or fire).
Suppression – The extinguishing of a wildfire. Also, reduction of tree growth due to competition from other trees.
Sustainability – Forest management that maintains the biological health of the forest and meets the needs of the present generation of humans without compromising the ability of future generations to meet their own needs.
Sustained Yield – An ideal forest management objective in which the volume of wood removed equals growth of the total forest.
Tactical operation center – A command post for military operations.
Thinning – A partial cut in an immature, overstocked stand of trees used to increase the stand's value by concentrating growth on the residual trees.
Traditional – Less desirable stems and species are removed so that the residual stand is less heterogeneous, horizontally and vertically.
Variable-density – The density of tree size removal varies across a stand so that the residual stand becomes more heterogeneous, horizontally and vertically.
Till – Unsorted (i.e., all size classes of rock intermixed) glacial sediment.
Timber stand improvement – Any practice that increases the value or rate of value growth in a stand of potential sawtimber trees.
Tracer – A bullet with a small pyrotechnic charge in its base that allows the path of the bullet to be seen at night.
Translocate – Move individual plants or animals from one place to another.
Transpiration – Loss of water from the internal tissues of vegetation via evaporation through the *stomata* of leaves.
Underburn – A wildfire or prescribed fire that burns only across the forest floor and understory vegetation.
Understory – The forest vegetation below the overstory.
Utility wood – Merchantable wood other than sawlogs.
Variable-retention – A silvicultural method based on the retention of structural elements or biological legacies (e.g., trees, snags, logs, etc.) from a harvested stand for integration into the next stand.
Veneer − Veneer is a thin sheet of wood that's been sliced or peeled from a log. Typically used to produce flat panels such as doors, cabinet tops and panels, parquet floors, and furniture.
Vertical concealment – What hiding cover provides for soldiers, vehicles, and equipment.
Vertical diversity – The number of canopy layers and their differences in species composition in a forest stand.
Waterbar – A ridge made across a sloping road or skid trail to divert runoff to one side.
Water-holding capacity – The total amount of water a volume of soil can hold after water has drained away.
Well-drained – A soil that allows water to percolate through it reasonably quickly and not pool.

Wildfire – An unplanned fire, started by natural or human causes, that burns out of control.
Windthrow – A tree or group of trees felled or snapped off by wind (also called blowdown).
Yarding – The initial hauling of a log from the stump to a collection point.