Upland Forest Vegetation Analysis: Phillips and Gordon Watersheds

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Loading a Ford Trimotor airplane with "goop" (DDT insecticide and a diesel oil carrier) during a western spruce budworm treatment project. This photograph was taken in June of 1951 at the Meacham, Oregon airstrip. Portions of the Phillips/Gordon analysis area were sprayed in both 1950 and 1952 to control spruce budworm population levels.

CONTENTS

INTRODUCTION

"Ecosystem analysis at the watershed scale" is a process to characterize the human, aquatic, riparian, and terrestrial conditions of a watershed. It is a systematic way to organize ecosystem information to better understand the impacts of management activities and disturbance processes in a watershed. The understanding gained from ecosystem analysis is critical for helping to sustain the health and resilience of natural resources administered on behalf of the American people (REO 1995).

Upland forests reflect the interaction of ecosystem elements called components, structures, and processes. Components are the organisms that make up an ecosystem (Manley and others 1995); they can include individual trees, aggregations of tree species called forest cover types, or combinations of cover types called life-forms (Veg Table 1).

Structures are the arrangement or distribution of ecosystem components (Manley and others 1995). They occur both horizontally (the spatial distribution of components across a landscape) and vertically (trees of varying height growing together in a multi-layered arrangement). Structures can consist of forest size classes, structural classes, or physiognomic groups (Veg Table 1).

Processes are the flow or cycling or energy, materials, and nutrients through space and time (Manley and others 1995). Forest processes include everything from photosynthesis and nutrient cycling to stand-replacing wildfires and insect outbreaks (Veg Table 1). In the Phillips and Gordon watersheds and in the Interior Northwest in general, disturbance processes have influenced vegetation conditions to a greater degree than other ecosystem processes (Clark and Sampson 1995; Oliver and Larson 1996).

Veg Table 1 demonstrates that ecological analysis is highly influenced by scale because ecosystem elements occur as hierarchies (Haynes and others 1996). Some elements are easily identified at one scale but not at another. That doesn't mean an element ceased to exist – it is just not apparent at the resolution of a different hierarchical level. For example, at the fine scale represented by the interior of a forest stand, individual trees can be readily distinguished. After moving back to the mid-scale, individual trees are imperceptible but species groups (cover types) become apparent. At a broad scale, discrete cover types can no longer be discerned although life form differences (forest versus non-forest) are obvious.

Veg Table 1. Selected examples of upland-forest ecosystem elements.

	ECOSYSTEM SCALE (HIERARCHICAL LEVEL)		
ELEMENTS	**FINE**	**MID**	**BROAD**
Components	Individual Trees	Cover Types	Life Forms (forest/nonforest)
Structures	Tree Size Classes	Structural Classes	Physiognomic Groups
Processes	Photosynthesis; Nutrient Cycling	Disturbances	Weather; Climate

Sources/Notes: Although they are shown individually in this table, it is important to note that ecosystem elements are interrelated – from an ecological perspective, they do not operate independently.

This report provides the results of an upland-forest vegetation analysis for the Phillips and Gordon watersheds. The following upland-forest ecosystem elements were analyzed: potential vegetation, cover types, size classes, structural classes, density classes, canopy layers, and disturbance processes. A variety of information sources were used for the analysis; the most important ones are described in Veg Table 2. Appendix one describes databases supporting the upland forest analyses.

Veg Table 2. Data sources used for analysis of upland-forest vegetation.

DATA SOURCE	DESCRIPTION OF DATA SOURCE
ADB (Activities Database).	ADB is a normalized, relational database system assembled and maintained by the Walla Walla Ranger District. Detailed information is stored about current and historical timber harvest, reforestation, site preparation, thinning, pruning, and other management activities.
Aerial Detection Surveys.	The Pacific Northwest Region of the Forest Service has been monitoring the impact of important forest insects since 1947, when the first aerial sketch map was prepared to provide information about a spruce budworm outbreak (Dolph 1980). Sketch maps have been completed annually since then; maps from 1980-1999 were used to characterize insect-caused damage for the Phillips/Gordon area.
CVS (Current Vegetation Survey).	CVS is an equal-interval grid system that sampled both forest and nonforest ecosystems. Each installation was a 5-point plot cluster occupying about 1 hectare (2.5 acres). Plots were installed every 1.7 miles (3.4 miles in Wilderness). Each 1.7-mile plot represents an area of 1,853 acres. 22 CVS plots were used to assess insect and disease risk for the analysis area.
EVG (Existing Vegetation).	EVG stores information about existing vegetation at the stand level. The original data was based on interpretation of aerial photography acquired in 1987 and 1988. For the Phillips/Gordon area, 49% of the polygons were characterized using photo-interpretation data from EVG.
GLO (Government Land Office) **Survey Notes.**	The GLO was formed in 1812 to survey the public domain. Their survey notes described vegetation and other features. Survey notes from the late 1850s to the early 1900s were used to assemble a database, and it was then used as a source of historical information for vegetation analyses.
Historical Forest-Type Maps.	Two historical forest-type maps were used for the analysis: one published in 1936 and another in 1958 (both were produced at a scale of 1 inch = 1 mile). The maps were published by the Pacific Northwest Forest and Range Experiment Station during a county-level forest survey program.
MSS (Managed Stand Survey).	MSS is a plot-based system that sampled young, managed stands with an average diameter of 3 inches or more – primarily plantations that had been thinned at least once. Each installation was a 5-point plot cluster covering about 1 acre. Thirteen MSS plots were installed in the Phillips/Gordon analysis area in 1990.
Potential Vegetation Map (PVEG).	Between May and November of 1998, a potential vegetation map was prepared by Karl Urban, Forest Botanist. The map contains over 20,000 polygons, each of which was assigned an Ecoclass code (plant association or community type). Management implications were also recorded for some of the polygons (potential for quaking aspen, white pine, etc.).
R6-TSE (Stand Exam).	Stand exams are designed to collect information at the stand level. Site, stand, and tree data are collected on temporary plots. For the Phillips/ Gordon analysis area, 51% of the polygons were characterized using stand examinations (including walk-through surveys).

Sources/Notes: See appendix 1 for more information about EVG, historical forest type maps, and stand exams.

ISSUES AND KEY QUESTIONS

Over the last 30 years, Blue Mountains forests have experienced increasing levels of damage from wildfire, insects, and diseases. Scientific assessments and studies have documented the high damage levels and speculated about their underlying causes (Caraher and others 1992, Gast and others 1991, Lehmkuhl and others 1994, Powell 1994, Shlisky 1994). Partly in response to the scientific assessments, the Blue Mountains area gained national notoriety for its forest health problems (Boise Cascade Corporation 1992, Joseph and others 1991, Lucas 1992, McLean 1992, Petersen 1992, Phillips 1995, Wickman 1992). In response to high levels of concern about forest health, both from the scientific community and the general public, the primary issue used in this analysis of upland forests was **forest sustainability**.

Forest sustainability is defined as being an ecosystem-oriented approach that allows the utilization of forests for multiple purposes (e.g., biodiversity, timber harvesting, non-wood products, soil and water conservation, tourism and recreation) without undermining their availability and quality for present and future generations (Gardner-Outlaw and Engelman 1999). This means that sustainable forests contain insects, diseases and other tree-killing agents, but not to the extent that they jeopardize the long-term integrity, resiliency, and productive capacity of the forest.

The upland-forest vegetation analysis was designed to respond to these key questions:

1. How do current forest conditions compare to those that existed historically?
2. Are current forest conditions considered to be ecologically sustainable over the long term?
3. If current forest conditions are considered to be unsustainable, how could they be changed in order to create a more sustainable situation?
4. How have disturbance processes shaped existing forest conditions, and what role might we expect them to play in the future?

The key questions were addressed during an analysis of the ecosystem elements. Specific analysis indicators were selected for each ecosystem element and are shown in Veg Table 3.

Veg Table 3. Key ecosystem elements and analysis indicators for upland-forest vegetation.

ELEMENTS	ANALYSIS INDICATORS	WHERE ANALYZED
Components and Structures	Forest Cover Types	Cur Con; Ref Con; Syn Int
	Forest Density Classes	Cur Con; Ref Con; Syn Int
	Forest Size Classes	Cur Con; Ref Con; Syn Int
	Forest Structural Classes	Cur Con; Ref Con; Syn Int
	Forest Canopy Layers	Cur Con; Ref Con; Syn Int
Processes	Potential Vegetation	Characterization
	Forest Disturbance Processes	Characterization
	Forest Insects (Impact)	Characterization
	Insect and Disease Risk	Synthesis and Interpretation

Sources/Notes: Analysis indicators were used to measure or interpret each of the ecosystem elements. The “where analyzed” column shows the “Ecosystem Analysis at the Watershed Scale” steps where the analysis indicator was used – “Cur Con” is current conditions; “Ref Con” is reference conditions; and “Syn Int” is synthesis and interpretation.

CHARACTERIZATION

Landscapes and the ecosystems that comprise them "age" through time. The series of changes that result in forest aging is called plant succession. Plant succession refers to temporal changes in both species abundance and vegetation structure following a disturbance event. Once initiated, plant succession follows a variety of pathways and occurs at varying rates of speed (Drury and Nesbit 1973, McCune and Allen 1985). The main factor affecting the speed and direction of plant succession is potential vegetation.

Upland forests in the analysis area can be thought of as the product of two important ecosystem processes: plant succession (as controlled by potential vegetation), and disturbance. Each of those processes is described individually in this section.

POTENTIAL VEGETATION

A distant summer view of the Blue Mountains shows a dark band of coniferous forest occurring above a lighter-colored grassland zone. Each of the two contrasting areas seems to be homogeneous, and the border between them appears sharp. A closer view, however, reveals great diversity within each zone and borders that are poorly defined. Herbaceous communities and stands of deciduous trees are scattered throughout the coniferous forest, and the species of dominant conifer changes from one site to another. At the foot of the mountains, fingers of forest and ribbon-like shrub stands invade the grassland zone for varying distances but become progressively less common before eventually disappearing altogether.

The Blue Mountains province, then, is actually broken up into a myriad of small units, most of which are repeated in an intricate, changing pattern. Making sense of this landscape pattern is possible using a concept called potential vegetation (PV). Potential vegetation implies that over the course of time and in the absence of future disturbance, similar plant communities will develop on similar sites. Potential vegetation information offers insights into vegetation-site relationships and can be helpful in projecting the type of vegetation expected under a particular set of ecological factors (Powell 2000).

The genetic structure of a plant species allows it to be adapted to a specific range of environmental conditions, which is called its ecological amplitude (Daubenmire 1968). Ecological amplitude is controlled by many factors such as elevation, aspect, geology and soil type – together they create the underlying foundation, or a "geomorphic template," upon which the biological landscape is constructed. The biophysical components of a plant's environment interact to form a temperature and moisture regime.

Because of their diverse landforms and topography, mountainous areas support a variety of temperature and moisture regimes. Since potential vegetation is influenced primarily by temperature and moisture, any significant change in an area's temperature or moisture status will cause a change in potential vegetation. In the Phillips and Gordon watersheds and other mountainous areas, temperature and moisture varies somewhat predictably with changes in elevation, aspect, and slope exposure (Powell 2000).

The potential vegetation associated with a particular set of temperature and moisture conditions is called a plant association. A plant association is named for the dominant plant species in its vegetation layers – the grand fir/twinflower plant association is dominated by grand fir in the overstory (tree) layer, and by twinflower in the undergrowth layer. In the analysis area, 32 forested plant associations have been identified (Johnson and Clausnitzer 1992, Johnson and Simon 1987; see Veg Table 4).

Sites that can support similar plant associations are grouped together as a plant association group (PAG). Similarly, closely related plant association groups are aggregated into a potential vegetation group (PVG). The end result is a hierarchy ranging from plant associations at the lowest level to PVGs at the highest level (Veg Table 4). Veg Table 5 summarizes selected characteristics of the PVGs. Veg Figures 1 and 2 (see appendix 2) show the location and distribution of upland-forest PAGs and PVGs, respectively.

Veg Table 4. Potential vegetation hierarchy for upland forests of the Phillips/Gordon analysis area

PVG	PAG	ABBREVIATION	COMMON NAME OF VEGETATION TYPE	AREA
Cold Upland Forest	Cold Dry	ABGR/VASC	Grand Fir/Grouse Huckleberry	100
		ABLA2/CAGE	Subalpine Fir/Elk Sedge	33
		ABLA2/POPU	Subalpine Fir/Polemonium pct	163
		ABLA2/VASC	Subalpine Fir/Grouse Huckleberry	440
		ABLA2/VASC/POPU	Subalpine Fir/Grouse Huckleberry/Polemonium	8
Moist Upland Forest	Cool Wet	ABGR/TABR/CLUN	Grand Fir/Pacific Yew/Queen's Cup Beadlily	823
		ABGR/TABR/LIBO2	Grand Fir/Pacific Yew-Twinflower	459
		ABLA2/STAM	Subalpine Fir/Twisted Stalk pct	90
	Cool Very Moist	ABGR/TRCA3	Grand Fir/False Bugbane	51
	Cool Moist	ABGR/CLUN	Grand Fir/Queen's Cup Beadlily	4,505
		ABGR/LIBO2	Grand Fir/Twinflower	2,480
		ABGR/VAME	Grand Fir/Big Huckleberry	6,536
		ABLA2/CLUN	Subalpine Fir/Queen's Cup Beadlily	1,378
		ABLA2/LIBO2	Subalpine Fir/Twinflower	91
		ABLA2/TRCA3	Subalpine Fir/False Bugbane	131
		ABLA2/VAME	Subalpine Fir/Big Huckleberry	1,360
		PICO(ABGR)/VAME	Lodgepole Pine (Grand Fir)/Big Huckleberry pct	240
	Warm Very Moist	ABGR/ACGL	Grand Fir/Rocky Mountain Maple	2,071
	Warm Moist	ABGR/ACGL-PHMA	Grand Fir/Rocky Mountain Maple-Ninebark pct	112
		ABGR/BRVU	Grand Fir/Columbia Brome	595
		PSME/ACGL-PHMA	Douglas-fir/Rocky Mountain Maple-Ninebark	17
		PSME/HODI	Douglas-fir/Oceanspray	1,437
Dry Upland Forest	Warm Dry	ABGR/CAGE	Grand Fir/Elk Sedge	259
		ABGR/CARU	Grand Fir/Pinegrass	262
		ABGR/SPBE	Grand Fir/Birchleaf Spirea	729
		GRASS/TREE MOSAIC	Grass/Tree Mosaic pct	4,288
		PIPO/CAGE	Ponderosa Pine/Elk Sedge	135
		PIPO/CARU	Ponderosa Pine/Pinegrass	581
		PIPO/SPBE	Ponderosa Pine/Birchleaf Spirea pct	33
		PIPO/SYAL	Ponderosa Pine/Common Snowberry	163
		PSME/CAGE	Douglas-fir/Elk Sedge	790
		PSME/CARU	Douglas-fir/Pinegrass	1,028
		PSME/PHMA	Douglas-fir/Ninebark	709
		PSME/SPBE	Douglas-fir/Birchleaf Spirea	4
		PSME/SYAL	Douglas-fir/Common Snowberry	333
		PSME/SYOR	Douglas-fir/Mountain Snowberry	148
		PSME/VAME	Douglas-fir/Big Huckleberry	229
	Hot Dry	PIPO/AGSP	Ponderosa Pine/Bluebunch Wheatgrass	210
		JUOC community types	Western Juniper plant community types	88

Sources/Notes: Adapted from Powell (1998). "Pct" after a common name refers to a plant community type (a seral or successional plant community); all other vegetation types are plant associations described in Johnson and Clausnitzer (1992). "Grass/tree mosaic" refers to a juxtaposition of forest and grassland communities that typically occurs as forested stringers embedded in a nonforest matrix of grassland or shrubland. Area figures (acres) include National Forest System lands only.

Veg Table 5. Selected characteristics of potential vegetation groups (PVGs) for upland forests.

PVG	AREA (ACRES)	DISTURBANCES	FIRE REGIME	PATCH SIZE	ELEVATION (FEET)	SLOPE (PERCENT)	DOMINANT ASPECTS
Dry Upland Forest	9,990	Fire Insects Harvest	Understory	1-2,000	4,228 (3,355-5,778)	35 (4-63)	Southeast Southwest East
Moist Upland Forest	22,376	Diseases Harvest Fire Insects	Mixed Severity	1-10,000	4,515 (3,218-5,773)	29 (2-62)	East Northeast West Southeast
Cold Upland Forest	721	Wind Insects Fire Diseases	Stand Replacement	1-1,000	5,003 (4,006-5,697)	21 (2-57)	East Northeast Southeast

Sources/Notes: Areas, elevations, slope percents, and aspects were summarized from the "ExistPG" database (see appendix 1). Patch size (acres) was taken from Johnson (1993). Disturbances, which show the primary agents affecting upland-forest ecosystems, were based on the author's judgment. For elevations and slope gradients, values are portrayed in the following format: average (minimum-maximum). Fire regime ratings have the following interpretation (Smith 2000):

Understory: fires generally not lethal to dominant vegetation – approximately 80% or more survives fire.
Mixed Severity: fires cause selective mortality, or varies between understory and stand replacement.
Stand Replacement: fires kill or top-kill the dominant vegetation – app. 80% or more is consumed/killed.

Some late-seral (successional) vegetation types persist on the landscape and have been referred to as plant community types in vegetation classifications. Forested plant community types have one or more dominant tree species in the overstory, and a well-developed undergrowth. The undergrowth may reflect the climax composition, but the overstory dominants are often long-lived seral trees that established after a previous disturbance event. In the analysis area, seven forested plant community types have been identified (Johnson and Clausnitzer 1992, Johnson and Simon 1987; see Veg Table 4).

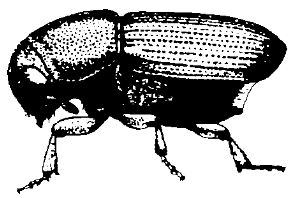
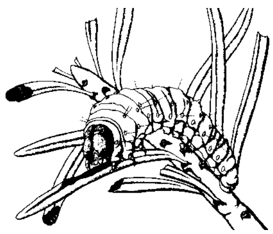
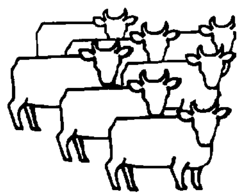
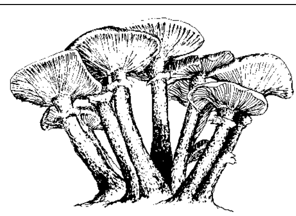
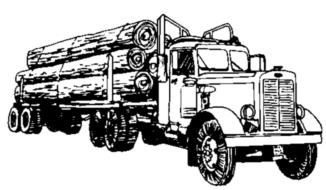
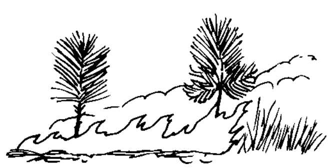
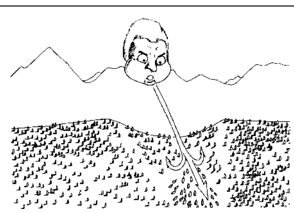
Why do we care about the potential vegetation (PV) of the Phillips/Gordon area? The main reason is that PV has an important influence on ecosystem processes. It is the "engine" that powers vegetation change – it controls the speed at which shade-tolerant species get established beneath shade-intolerant trees, the rate at which forests produce and accumulate biomass, and the impact that fire, insects, pathogens, and other disturbance agents have on forest composition and structure. The implications of those processes are predictable, at least to some extent, for a reason – they can be related to PV, and research has shown that sites with the same PV behave in a similar way (Cook 1996, Daubenmire 1961).

FOREST DISTURBANCE PROCESSES

Disturbance processes have a profound influence on the structure and composition of vegetation. Veg Table 6 describes seven disturbance agents that have influenced upland-forest vegetation in the Phillips/Gordon analysis area, although they are certainly not the only ones to have done so.

Much of the forested land within the analysis area was affected by various disturbance agents in the recent past. Information provided by the Pacific Northwest Region's annual aerial survey program was used to assess insect impacts (see Veg Table 2 for information about aerial detection surveys). Insect activity was recorded on a "sketch map;" sketch maps for a 20-year period (1980-1999) were used to summarize the areal extent of recent insect impact on upland-forest sites (Veg Table 7).

Veg Table 6. Important disturbance agents of the Phillips/Gordon analysis area.

	**Bark Beetles.** Douglas-fir beetle and fir engraver are the main bark beetles affecting mid-elevation mixed-conifer forests (see Veg Table 7). Mountain pine beetle has affected both ponderosa and lodgepole pines, with large outbreaks occurring in the mid 1940s (Buckhorn 1948) and in the 1970s (Carter 1976). Western pine beetle was very active in the late 1940s, particularly after ranchers began girdling ponderosa pine trees to clear land for grazing (Buckhorn 1947).
	**Defoliating Insects.** The analysis area experienced 2 spruce budworm outbreaks over the last 50 years: one in 1944–1958, and another from 1980–1992. In the first outbreak, the entire analysis area was defoliated to some degree by 1949; parts of it were sprayed with DDT in 1950 and 1952 (Dolph 1980). In the second outbreak, defoliation peaked by the late 1980s and B.t. was sprayed in 1988 and 1992 (Veg Figure 3). Douglas-fir tussock moth defoliated mixed-conifer forest in 1972-1974; one small area of private land in the Gordon Creek drainage (subwatershed 7B) was treated with DDT in June of 1974.
	**Grazing.** Historical cattle and sheep grazing in the analysis area had significant impacts on vegetative conditions, particularly along ridgetops used as sheep driveways or as bedding grounds (Galbraith and Anderson 1970, Irwin and others 1994, Tucker 1940). Immense bands of sheep grazed in the Blue Mountains in the late 1800s and the early 1900s, often causing enduring changes in plant composition and fine-fuel continuity (Coville 1898, Griffiths 1903, Humphrey 1943).
	**Parasites and Pathogens.** Root diseases tend to be localized, but can cause significant tree mortality in affected areas. Armillaria root disease is found throughout the mixed-conifer type; Annosus root disease is associated with partial-cut timber harvest areas, especially if fir stumps were created by the harvest. Dwarf mistletoes, a tree parasite, affect ponderosa pine, lodgepole pine, western larch, and Douglas-fir in the Phillips/Gordon analysis area.
	**Timber Harvest.** Timber harvest has been used to produce the wood commodities desired by a human society. Harvest in the Blue Mountains began in the 1880s but at a much reduced rate as compared to other pine forests in eastern Oregon (Weidman 1936). From the 1940s on, however, harvesting of ponderosa pine increased to meet the demand for post-war housing. The main timber harvest era occurred in the mid 1970s when at least 51 million board feet were harvested to salvage trees killed or damaged during a Douglas-fir tussock moth outbreak.
	**Wildfires.** A large fire occurred in the analysis area about 1850; it came "from the present Umatilla Indian Reservation, burned up the river Umatilla, then turned north along the heads of the Walla Wallas, and reached as far as the head of the Wenaha" (Kent 1904). When a forest-type map of Oregon was published in 1900, portions of 2 burnt areas were shown in the Phillips/Gordon area – one was 118 acres and the other 2,726 acres (Thompson and Johnson 1900).
	**Windstorms.** A major windstorm occurred on January 8, 1990. It affected subalpine fir/Engelmann spruce stands along Highway 204 and in the Tollgate/Spout Springs area. The infamous 1962 Columbus Day windstorm, which caused extensive damage throughout the Pacific Northwest, had little impact in the analysis area. Windstorms were frequently mentioned as a disturbance agent in historical accounts of the Blue Mountains (Smith and Weitknecht 1915).

Sources/Notes: Based on annual aerial detection surveys and on unpublished records available at the Walla Walla Ranger District and at the Umatilla National Forest Supervisor's Office.

Veg Table 7. Area (acres) of insect-caused forest damage in the Phillips/Gordon analysis area, 1980-1999.

YEAR	MIXED-CONIFER BEETLES	PINE BEETLES	WESTERN SPRUCE BUDWORM	OTHER	TOTAL	PERCENT OF AREA
1980	267	789	—	—	1,057	2.6
1981	224	49	—	—	273	0.7
1982	98	—	31	—	129	0.3
1983	48	96	—	—	145	0.4
1984	120	—	—	—	120	0.3
1985	38	—	4,397	—	4,435	11.1
1986	—	—	33,664	—	33,664	84.1
1987	—	—	39,498	—	39,498	98.6
1988	4,500	—	19,219	—	23,720	59.2
1989	2,916	47	8,395	—	11,358	28.4
1990	2,280	9	16,708	—	18,996	47.4
1991	156	—	34,093	—	34,249	85.5
1992	91	—	34,996	51	35,139	87.7
1993	32	1	—	—	33	0.1
1994	167	—	—	33	200	0.5
1995	253	—	—	13	265	0.7
1996	10	—	—	—	10	0.0
1997	637	22	—	—	659	1.6
1998	5	5	—	—	10	0.0
1999	107	—	—	100	207	0.5

Sources/Notes: Areas (acres) were derived from aerial detection surveys (sketch maps) completed by the Pacific Northwest Region of the Forest Service (see Veg Table 2). Note that area figures in this table include National Forest System (NFS) lands only (including the Wallowa-Whitman NF). The "mixed-conifer beetles" category includes Douglas-fir beetle, fir engraver, spruce beetle, and western balsam bark beetle. "Pine beetles" includes mountain pine beetle in either lodgepole pine or ponderosa pine, *Ips* beetle in pine, and western pine beetle. "Other" includes larch casebearer, root disease, and sawfly. Some areas on the sketch maps show more than one agent; in those instances, only the first (primary) agent was used for this summary. Totals were not computed for the damage category columns because when insect activity is on-going in an area, the same acres may be included from one year to another (e.g., acreage values are not mutually exclusive from year to year). The "percent of area" values were calculated by dividing the "total" values by the NFS acres in the analysis area (40,046 acres for Phillips/Gordon).

Three disturbance processes have had an important influence on upland-forest conditions and will be discussed individually – defoliating insects, fire, and timber harvest.

Defoliating Insects. Western spruce budworm is an unobtrusive inhabitant of mixed-conifer forests throughout western North America. It feeds primarily on Douglas-fir, grand fir, subalpine fir, and Engelmann spruce. Occasionally, after weather and other environmental conditions become ideal for its growth and survival, budworm populations explode in what is called an outbreak (epidemic). Budworm outbreaks tend to be cyclic, with eruptive episodes covering large landscapes every 15 to 30 years. Forests comprised mostly of pines or western larch have little defoliation risk because those species are seldom fed upon by western spruce budworm.

The Phillips/Gordon ecosystem analysis area has experienced two budworm outbreaks during the last 50 years. Early in the first outbreak (1944-1958), most of the budworm-host type in the analysis area was defoliated to some degree. In response to the defoliation and its resultant tree damage (top-killing and mortality), all of the Phillips/Gordon area was sprayed in either 1950 or 1952 to reduce budworm populations to non-damaging levels (Dolph 1980). DDT, a chemical insecticide applied in a fuel oil diluent, was applied during those spray projects.

DDT became a popular insecticide after it was used to control Douglas-fir tussock moth in northern Idaho and in the northern Blue Mountains west of Troy, Oregon in 1947 (Wickman and others 1973), and after it was applied experimentally to suppress spruce budworm populations on the Heppner Ranger District and adjacent Kinzua lands in 1948 (Eaton and others 1949). Although commonly used against defoliating insects, land managers eventually realized that DDT failed to provide long-term control because the underlying problem had not been addressed – a proliferation of insect-host type throughout the western United States (Carolin and Coulter 1971, Fellin 1983).

After the earlier outbreak collapsed in 1958, western spruce budworm remained at endemic levels until 1980, when another outbreak began in mixed-conifer stands near Cove, Oregon. The 1980-1992 outbreak moved from south to north in the Blue Mountains; the Phillips/Gordon watersheds did not experience substantial defoliation until 1986, although it then continued until 1992 (see Veg Table 7).

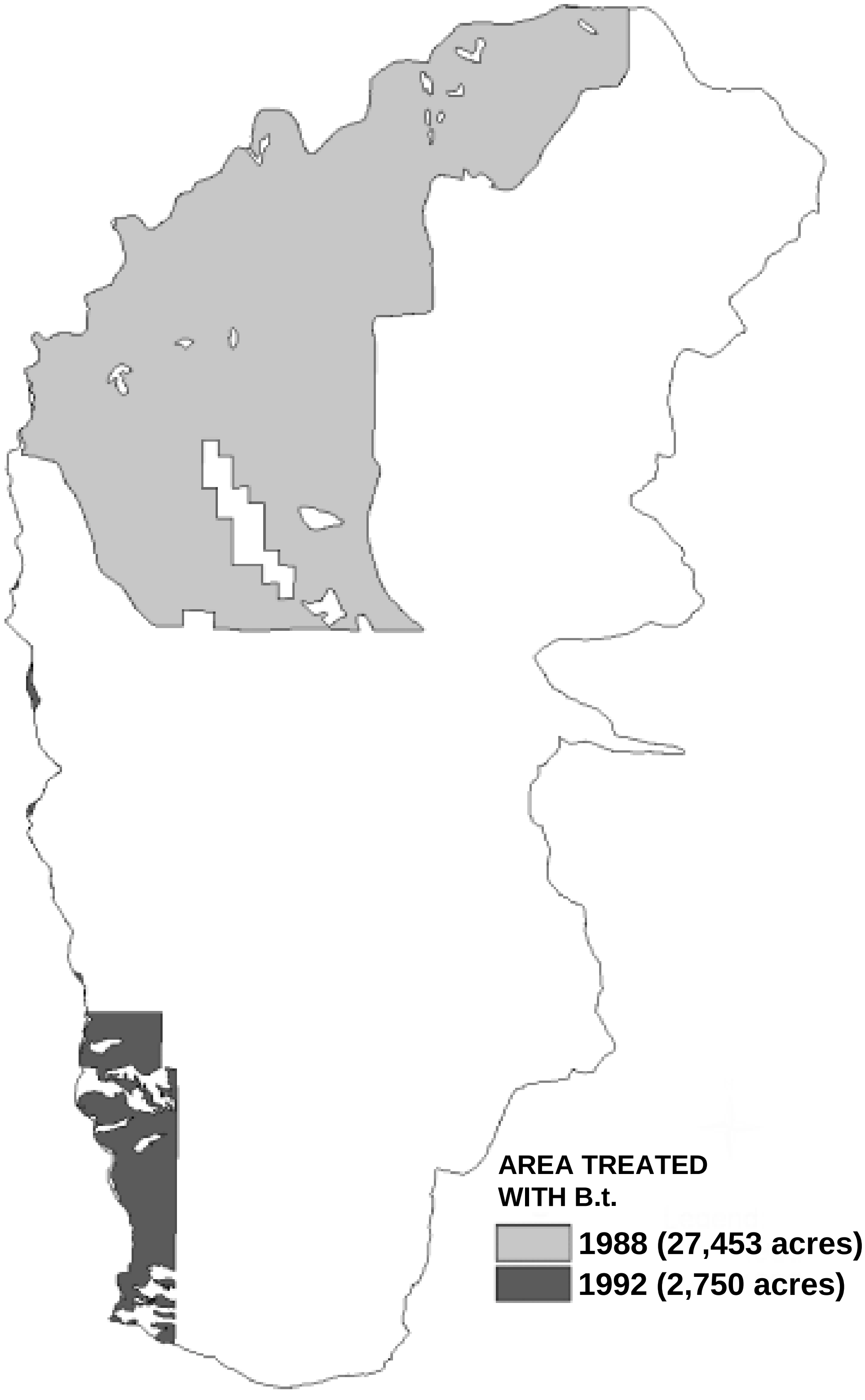
Portions of the 1980s budworm outbreak were treated with a bacterial insecticide called B.t. *(Bacillus thuringiensis)* in 1988 and 1992 (Veg Figure 3). As was the case for the 1950s DDT treatments, application of B.t. during the recent outbreak successfully reduced budworm populations in the short term, but had little long-term impact on the outbreak itself or on host-tree damage (Powell 1994, Torgersen and others 1995).

Douglas-fir tussock moth defoliates true firs and Douglas-firs from the top down, killing trees outright or setting them up for future attack by bark beetles such as Douglas-fir beetle or fir engraver. Like budworm, Douglas-fir tussock moth is a native component of coniferous ecosystems and it has been active in the Phillips/Gordon area for as long as a food supply has been available there. For example, a dendrochronology[1] analysis for the Drumhill Ridge area of the Walla Walla Ranger District indicates that Douglas-fir tussock moth may have defoliated mixed-conifer stands in that area between 1843 and 1845, 1852 and 1854, and in 1875 (Wickman and others 1994) (note that Drumhill Ridge adjoins the Phillips/Gordon analysis area at its southwest corner).

Historically, budworm and tussock moth outbreaks were smaller in extent than the most recent outbreaks because the insect food base (particularly mixed-conifer stands dominated by grand fir and Douglas-fir) was less continuous then (Hessburg and others 1994, 1999).

The last major tussock moth outbreak occurred between 1972 and 1974, when mixed-conifer stands throughout the analysis area were defoliated. This 1970s outbreak in the Interior Northwest was the largest and most severe one ever recorded (Brookes and Campbell 1978). In 1974, stands north of Mount Emily and west of Summerville (adjacent to the southwest corner of the analysis area) were treated with DDT to minimize defoliation-related damage, although tussock moth outbreaks have a short lifespan and tend to collapse on their own after about 3 years. One small area of private land in the Gordon Creek drainage (it occurs in subwatershed 7B) was also treated with DDT (Graham and others 1975).

[1] Dendrochronology involves interpretation of tree cores to infer climate and fire cycles, insect outbreaks, etc.



Veg Figure 3. Areas treated with *Bacillus thuringiensis* (B.t.) in 1988 or 1992 to control western spruce budworm (treatment map provided by USDA Forest Service, Pacific Northwest Region, Forest Insect and Disease Group). By the mid 1980s, B.t. was the insecticide of choice because of its low risk to the environment and human health. Use of B.t. allowed land managers to maintain more of the pretreatment arthropod diversity than had been possible with carbaryl, acephate, mexacarbate or the other chemical insecticides in common usage at that time. Note that research found that application of insecticides during the 1980-1992 spruce budworm outbreak had little long-term impact on either budworm populations or host-tree damage (Powell 1994, Torgersen and others 1995).

Although application of DDT was an important response to tussock moth defoliation in the early 1970s, it was certainly not the only one – many salvage sales to harvest damaged and dead timber were also completed. The first tussock moth salvage sale on the Umatilla National Forest was sold on November 28, 1972; the last of forty sales was sold on September 3, 1974. In the Phillips/Gordon analysis area, at least 51.1 million board feet was harvested in five tussock-moth salvage sales: Dry (subwatershed 84I), Craig (84C), Middle (84B), Gordon (7B), and Balloon (7A).

One result of the 1970s outbreak was that the Forest Service instituted an early-warning system for Douglas-fir tussock moth. It utilizes pheromone traps to monitor tussock moth population levels (pheromones are biochemicals whose odor is used to attract insects – in this case, male tussock moths). The early-warning system was developed in the late 1970s, and then implemented throughout the western United States in 1980. Since tussock moth develops rapidly, the early-warning system was designed to predict population increases with enough lead time to implement a treatment program before serious damage to high-value areas could occur. It is interesting that the early-warning system indicates that the Blue Mountains are now heading into another tussock-moth outbreak (Ragenovich 2000).

Fire. Fire was an important ecosystem process on dry-forest sites in the Phillips/Gordon analysis area, and on some of the moist-forest ones as well. Within these environments, plants have been exposed to the long-term influence of fire. Some species such as ponderosa pine, western larch, snowbrush ceanothus, serviceberry, and bluebunch wheatgrass are considered to be "fire adapted." That is, over many centuries, they evolved strategies to help them maintain populations on sites where fires occurred frequently. Other vegetation such as Douglas-fir is not as well adapted to recurrent fire. Historically, frequent fires tended to reduce the abundance of young Douglas-firs because their thin bark and low-hanging branches made them vulnerable to fire damage (Veg Table 8).

Veg Table 8. Fire resistance characteristics for major conifer species of the Umatilla National Forest.

TREE SPECIES	Bark Thickness	Rooting Habit	Bark Resin (Old Bark)	Branching Habit	Stand Density	Foliage Flammability	Fire Resistance
Western Larch	Very thick	Deep	Very little	High and very open	Open	Low	Very high
Ponderosa Pine	Very thick	Deep	Abundant	Moderately high & open	Open	Medium	High
Douglas-fir	Very thick	Deep	Moderate	Moderately low & dense	Moderate to dense	High	High
Grand Fir	Thick	Shallow	Very little	Low and dense	Dense	High	Medium
Western White Pine	Medium	Medium	Abundant	High and dense	Dense	Medium	Medium
Lodgepole Pine	Very thin	Medium	Abundant	Moderately high & open	Dense	Medium	Low
Engelmann Spruce	Thin	Shallow	Moderate	Low and dense	Dense	Medium	Low
Subalpine Fir	Very thin	Shallow	Moderate	Very low and dense	Moderate to dense	High	Very low

Sources/Notes: Adapted from Powell (2000). Species rankings reflect the predominant situation for each trait. A species trait is not absolute – it can vary during the lifespan of an individual tree, and from one individual to another in a population. For example, grand fir's bark is thin when young, but thick when mature.

Many wildfires were ignited by lightning storms in mid or late summer (Plummer 1912) but a large number were apparently started by American Indians (Barrett 1980, Boyd 1999, Robbins 1997). Fire was used by American Indians to clear brush for improved hunting access, for entertainment, and for a variety of cultural activities. Oregon Indians used smoke to harvest pandora moths – after fire was run through an infested pine stand, the caterpillars would drop from the trees to the ground and were then gathered for food (Pyne 1982).[2]

Fire effects were often described in early journals. A recent book synthesizes journals and other writings from 19th century travelers on the Blue Mountains portion of the Oregon Trail (Evans 1991). When 66 journal accounts from that book were analyzed, 89% of them referred to open ponderosa pine stands and 54% noted burned underbrush or grassy glades, much smoke in late summer and fall, or a lack of underbrush and dense thickets (Wickman and others 1994). Apparently in the Blue Mountains, the forest at low and mid elevations was comprised mostly of ponderosa pine, the pine forests were open and park-like with grass as the predominant undergrowth vegetation, and fire was a regular autumnal occurrence.

An historical account of wildfire in the northern Blue Mountains was provided by Washington Irving in a book entitled "The Adventures of Captain Bonneville, U.S.A." (Irving 1837).[3] Captain Bonneville and his party of trappers crossed the Blue Mountains when traveling between the Snake and Columbia Rivers in August of 1833. Irving vividly describes their encounter with forest fires:

> It was the season of setting fire to the prairies. As he advanced, he began to perceive great clouds of smoke at a distance, rising by degrees, and spreading over the whole face of the country. The atmosphere became dry and surcharged with murky vapor, parching to the skin, and irritating to the eyes. When traveling among the hills, they could scarcely discern objects at the distance of a few paces; indeed, the least exertion of the vision was painful. There was evidently some vast conflagration in the direction towards which they were proceeding; it was as yet at a great distance, and during the day they could only see the smoke rising in larger and denser volumes, and rolling forth in an immense canopy. At night, the skies were all glowing with the reflection of unseen fires; handing in an immense body of lurid light, high above the horizon.
>
> During four days that the party were ascending Gun Creek, the smoke continued to increase so rapidly that is was impossible to distinguish the face of the country and ascertain landmarks. Fortunately the travelers fell upon an Indian trail, which led them to the head waters of the Fourche de Glace, or Ice River, sometimes called the Grand Rond. Here they found all the plains and valleys wrapped in one vast conflagration; which swept over the long grass in billows of flame, shot up every bush and tree, rose in great columns from the groves, and sent up clouds of smoke that darkened the atmosphere. To avoid this sea of fire, the travelers had to pursue their course close along the foot of the mountains; but the irritation from the smoke continued to be tormenting.
>
> The country about the head waters of the Grand Rond spreads out into broad and level prairies, extremely fertile, and watered by mountain springs and rivulets. These prairies are resorted to by small bands of the Skynses,[4] to pasture their horses as well as to banquet upon the salmon which abound in the neighboring waters.

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[2] American Indians used most of the life stages of pandora moth for food – the Klamath and Modoc tribes dug up and used the pupae in a concoction called "bull quanch," whereas the Piutes gathered and dried the mature caterpillars and combined them with vegetable-type materials in a dish called "peage" (Patterson 1929).

[3] In 1832, Captain Bonneville arranged a 26-month leave from the U.S. Army and organized a 110-man expedition to trap beaver. In 1835, Washington Irving met him in Washington, D.C. when the Captain was trying to gain Army reinstatement after overstaying his leave. While awaiting reinstatement, Bonneville wrote up his experiences in the West. He later turned the manuscript over to Irving and suggested that he rewrite it, which resulted in "The Adventures of Captain Bonneville, U.S.A."

[4] Bonneville referred to the Cayuse as "Skyuses," a common practice of the time. His handwriting must have been difficult to read because Irving translated the word as "Skynses" (Evans 1990).

> The travelers continued, for many days, to experience great difficulties and discomforts from this wide conflagration, which seemed to embrace the whole wilderness. The sun was for a great part of the time obscured by the smoke, and the loftiest mountains were hidden from view. Blundering along in this region of mist and uncertainty they were frequently obliged to make long circuits, to avoid obstacles which they could not perceive until close upon them. The Indian trails were their safest guides, for though they sometimes appeared to lead them out of their direct course, they always conducted them to the passes.
>
> The flames, which swept rapidly over the light vegetation of the prairies, assumed a fiercer character, and took a stronger hold amidst the wooded glens and ravines of the mountains. Some of the deep gorges and defiles sent up sheets of flame, and clouds of lurid smoke, and sparks and cinders, that in the night made them resemble the craters of volcanoes. The groves and forests, too, which crowned the cliffs, shot up their towering columns of fire, and added to the furnace glow of the mountains. With these stupendous sights were combined the rushing blasts caused by the rarefied air, which roared and howled through the narrow glens, and whirled forth the smoke and flames in impetuous wreaths. Ever and anon, too, was heard the crash of falling trees, sometimes tumbling from crags and precipices, with tremendous sounds.
>
> In the daytime, the mountains were wrapped in smoke, so dense and blinding that the explorers, if by chance they separated, could only find each other by shouting. Often, too, they had to grope their way through the yet burning forests, in constant peril from the limbs and trunks of trees, which frequently fell across their path. At length they gave up the attempt to find a pass as hopeless, under actual circumstances, and made their way back to the camp to report their failure.[5]
>
> **The Adventures of Captain Bonneville, U.S.A. (Irving 1837).**

Large fires were common during Euro-American settlement of the Interior Northwest. Many fires were set by emigrants, either accidentally or intentionally. Miners often set fires to clear away brush and forest debris, thereby exposing rock outcrops for inspection by prospectors (Veblen and Lorenz 1991). Likewise, some early fires were started by livestock ranchers to remove brush and promote grass growth (Harley 1918). Whether of human or natural origin, large fires definitely occurred in the Phillips/Gordon analysis area during the presettlement era:

> Practically every portion of the reserve has suffered more or less from fire. The largest and most important of these was one which came from the present Umatilla Indian Reservation about fifty years ago, burned up the river Umatilla, into the reserve, then turned north along the west slope across the heads of the Walla Wallas, and reached as far as the head of the Wenaha. This burn has generally restocked finely, principally to tamarack and lodgepole pine.
>
> **The Proposed Wenaha Forest Reserve (Kent 1904).**

Even though emigrants caused some fires, they also contributed to conditions that limited fire intensity and spread. For instance, immense bands of sheep grazed in the Blue Mountains during the latter part of the nineteenth century (Coville 1898, Galbraith and Anderson 1970, Tucker 1940), consuming herbaceous vegetation that otherwise would have been available as fine fuel for a fire (Case and Kauffman 1997, Irwin and others 1994). Veg Figure 4 summarizes historical grazing trends for three classes of livestock (cattle and calves, sheep and lambs, horses and ponies). It pertains to Union County, Oregon, which comprises the majority of the analysis area.

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[5] After his scouting party returned unsuccessfully from their 20-day attempt to locate an "easy" pass, Bonneville's party crossed over the divide north of Mt. Emily (in the Phillips/Gordon analysis area) and went down the Umatilla River (Evans 1990).

Veg Figure 4. Number of grazing animals for Union County, Oregon (from Bureau of Census 1895, 1902, 1913, 1922, 1927, 1932, 1942, 1946, 1952, 1956, 1961).

After livestock removed most of the herbaceous vegetation from beneath forest stands, it was very difficult for fires to spread through them. That was particularly true for open stands of ponderosa pine because herbaceous vegetation was an important fuel component. When heavy livestock grazing coincided with effective suppression of low-intensity surface fires, the result was an increase in forest regeneration (Rummell 1951), as described in this account:

> And in open, overmature stands this [yellow pine] reproduction is even now so dense and large in many places as to practically prevent grazing. This advance reproduction has mostly come in during the last 25 or 30 years, and is due to the protection from fire which the forest has received partly by the Forest Service and partly by the unconscious efforts of the settlers and stockmen.
>
> **Yellow Pine Management Study in Oregon in 1916 (Weitknecht 1917).**

On dry-forest sites that historically supported open (park-like) ponderosa pine, suppression of the native disturbance regime – frequent surface fires (underburning) – had the unintended consequence of allowing grand firs and Douglas-firs to replace the pines. By the late 1970s, it was believed that at least 25 percent of the historical ponderosa pine type had been replaced with mixed-conifer forest (Barrett 1979); the reduction was apparently much greater than that for the southern Blue Mountains (Malheur National Forest), where ponderosa pine declined by more than half between 1936 and 1980 (Powell 1994).

If fire suppression caused major shifts in species composition, then why weren't those changes recognized earlier? Actually, it turns out that many of them were recognized, but weren't acted upon because of the prevailing attitudes of the time. As an example, the following questions and observations were made by a prominent fire researcher over fifty years ago.

> It is obvious that the present policy of attempting complete protection of ponderosa pine stands from fire raises several very important problems. How, for instance, will the composition of the reproduction be controlled? If ponderosa pine is desired on vast areas how, unless fire is employed, can other species such as white fir be prevented from monopolizing the ground? On the other hand, if it is de-

> cided to permit such species as white fir to come in under mature ponderosa pine, how much of the public's money are foresters justified in spending in trying to keep fire out? Even with unlimited funds, personnel, and equipment, can they give reasonable assurance that they can continue to keep such extremely hazardous stands from burning up? If they feel reasonably sure of this, can they then give assurance that the timber products of such stands will be more valuable than those that might otherwise be derived from ponderosa pine and will in addition justify the high protection costs?
>
> **Fire as an Ecological and Silvicultural Factor in the Ponderosa Pine Region (Weaver 1943).**

Timber Harvest. Some level of timber harvest has occurred ever since the Blue Mountains were settled by Euro-American emigrants. The first commercial logging in the Northwestern pine region of eastern Oregon and Washington began around 1890 (Weidman 1936), although limited harvesting occurred during the preceding 25 years to meet the needs of miners and early settlers. Some of the first roads reaching into the Blue Mountains were wagon roads for hauling wood and rails out to farms and ranches.

A local demand for construction timbers – trusses for mine tunnels and wooden viaducts to carry water – resulted in the first timber harvests in the Blue Mountains. Within a year after gold was discovered in the John Day River valley (in June of 1862 near Canyon City, Oregon), an enterprising person opened a sawmill to cut lumber for miners who were building flumes and sluices (Robbins 1997).

During the Euro-American settlement era, timber met a variety of the homesteaders' needs including logs for homes, posts and poles for corrals, and rails for fencing. The resinous, durable woods of ponderosa pine and western larch were ideal for providing many of those necessities (Robbins 1997, Tucker 1940). In the early days, lodgepole pine was harvested to provide an important heat source; the Meacham area, located southwest of the Phillips and Gordon watersheds, averaged more than 9,000 cords of wood a year (mostly fuelwood) between 1884 and 1924 (Tucker no date).[6]

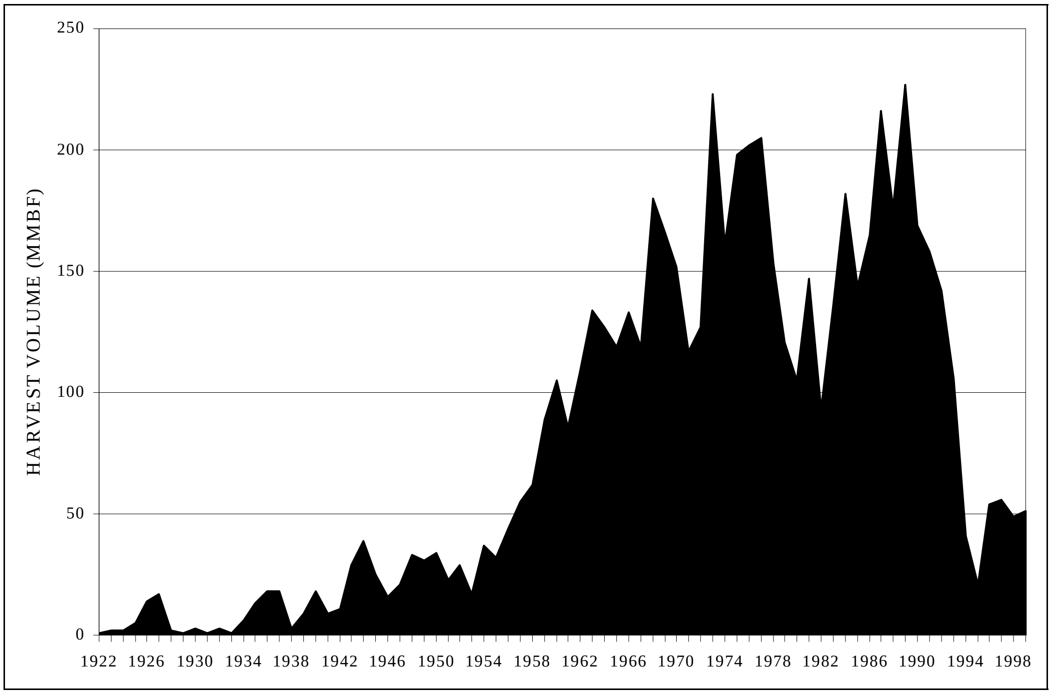
After World War II, ponderosa pine and other species were intensively harvested to feed a rapidly growing market for clear lumber for home construction, railroad ties, and to fabricate shipping boxes for apples and other agricultural products (Bolsinger and Berger 1975, Gedney 1963, Robbins 1997).

Timber harvest has had a widespread but somewhat limited impact on vegetation conditions in the analysis area. For national forest lands located in eastern Oregon and eastern Washington, timber harvest levels declined by 72 percent between 1990 and 1995 (O'Laughlin and others 1998). That trend is clearly reflected in the timber harvest history for the Umatilla National Forest (Veg Figure 5); recent harvest levels on the Forest (and in the analysis area) are the lowest since the mid- to late-1950s.

Veg Table 9 summarizes tree density for all thirteen of the managed stand survey plots located in the Phillips/Gordon analysis area. It shows that reforestation following timber harvest has been successful when post-harvest tree density is used as a criterion to measure success – on average, the sampled plantations support 799 trees per acre.

Plantations with high tree densities will eventually need to be thinned to maintain tree vigor and to avoid future forest health problems. Delaying some of those thinnings until the stands are pole-sized could help address a deficiency of the stem exclusion closed canopy structural class in the analysis area (see Veg Table 27). For forest health and a variety of other reasons, early-seral tree species should be retained in the thinnings.

[6] Converted to board feet at 2 cords per thousand, 9000 cords was equivalent to an annual harvest level of 4½ million board feet.



Veg Figure 5. Timber harvest history for the Umatilla National Forest, 1922-1999. After 1993, harvest declined dramatically on the Umatilla NF, and that trend is also true for the analysis area.

Veg Table 9. Tree density (trees per acre) for managed stand survey plots located in the analysis area.

PLOT	PLANT ASS.	PAG	PP	LP	WL	DF	ES	GF	SF	PY	TOTAL
2753	GF/CLUN	CM	141	0	29	0	624	213	0	0	1,008
2761	GF/VAME	CM	153	0	0	16	4	36	0	0	209
2762	GF/VAME	CM	23	0	0	0	0	213	0	40	276
2763	GF/LIBO2	CM	0	0	967	44	665	201	0	0	1,877
2772	GF/SPBE	WD	139	0	0	120	0	28	0	0	287
2780	DF/CAGE	WD	108	0	0	68	0	4	0	0	180
2783	GF/LIBO2	CM	0	0	56	80	600	779	0	0	1,515
2787	GF/VAME	CM	0	0	269	87	532	665	0	0	1,553
2793	SF/VAME	CM	8	72	0	0	173	60	136	0	449
2822	GF/CLUN	CM	0	0	20	4	1,095	407	0	0	1,525
2834	GF/VAME	CM	77	0	11	8	44	181	0	0	321
2835	GF/VAME	CM	4	0	4	53	108	729	0	0	899
2836	DF/SYAL	WD	4	0	8	200	0	60	0	20	292
		Mean	51	6	105	52	296	275	10	5	799
	Percent of Mean Total		6.4	0.7	13.1	6.5	37.1	34.4	1.3	0.6	

Sources/Notes: Based on 13 managed stand survey plots installed in the Phillips and Gordon watersheds in 1990 (see Veg Table 2 for more information about MSS plots). Plant associations are described in Veg Table 4 (note that GF refers to ABGR, DF refers to PSME, and SF refers to ABLA2). PAG refers to plant association group (CM refers to Cool Moist, WD refers to Warm Dry). Species are arranged by seral status (from early-seral at left to late-seral at right) and their codes are as follows: PP, ponderosa pine; LP, lodgepole pine; WL, western larch; DF, Douglas-fir; ES, Engelmann spruce; GF, grand fir; SF, subalpine fir; PY, Pacific yew.

CURRENT CONDITIONS

Forest Cover Types. The characterization section of this report described the potential vegetation of the Phillips/Gordon analysis area, e.g., the plant composition that would be expected to occur if disturbances were prevented from interrupting plant succession in the future. This section describes forest composition as it exists right now, regardless of whether it represents the potential vegetation or a transitory (seral) stage resulting from wildfire, timber harvest, windstorms, or another disturbance process.

Tree species occur in either pure or mixed stands called forest cover types. Cover types are classified using existing tree composition, so they reflect what a land manager finds on the ground and deals with on a daily basis. Forest cover types are based on a predominance of stocking[7] and are seldom pure – the grand fir type, for example, has a majority (50% or more) of grand fir trees, but it may also contain Douglas-fir, western larch, ponderosa pine, or other species.

Veg Tables 10 and 11 summarize the area of existing forest cover types for the Phillips/Gordon area. They show that the predominant forest cover type is grand fir (43% of upland forests in the analysis area have grand fir as the plurality or majority species), followed by Douglas-fir (21%), ponderosa pine (14%), and western larch (5%). Forests with a plurality or majority of subalpine fir, lodgepole pine or Engelmann spruce are uncommon because each of them occupies less than 5% of the analysis area. Veg Figure 6 (see appendix 2) shows forest cover types in the Phillips/Gordon area.

Veg Table 10 also shows that the analysis area has a relatively well balanced representation of pure and mixed forest (in actuality, even the pure stands contain tree species other than the primary one). Pure stands (cover types where one species is the majority) comprise 52% of the Phillips/Gordon forested area; mixed stands (types where no single species is the majority) comprise 48% of that area.

About 9% of the analysis area supports nonforest vegetation, most of which is grassland. Dry meadows and bunchgrass communities (dominated by fescues and bluebunch wheatgrass) are common grassland types. Shrublands comprise a relatively small proportion of the nonforest vegetation, although a diverse mix of shrub types are present. Often, the nonforest vegetation occurs as a juxtaposition of forest and grassland referred to as a grass-tree mosaic (GTM). In general, GTM consists of forested stringers alternating with nonforest communities (grasslands and shrublands).

Forest Density Classes. Half of the Phillips/Gordon analysis area has been examined using stand examinations. Stand exams provide quantified data suitable for characterizing stand density (trees per acre or basal area per acre) but they do not provide estimates of canopy (crown) cover. The other half of the analysis area was characterized using photo-interpretation surveys that provide canopy cover information but no estimates of basal area or trees per acre.

To provide a forest density measure that is compatible with both data sources, basal area values from stand exams were converted to their equivalent canopy cover using mathematical equations developed during an elk thermal cover study (Dealy 1985).

Veg Tables 12 and 13 summarize the area of existing forest density classes for the Phillips and Gordon watersheds. They show that the predominant situation is high-density forest (greater than 70% canopy cover; 37% of the forested portion of the analysis area), followed by low density (10-40% cover; 35% of the forested area) and moderate density (41-70% cover; 28% of forest). Veg Figure 7 (see appendix 2) shows forest density classes in the Phillips/Gordon area.

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[7] Forest cover types are based on species predominance using basal area. Types where one species comprises more than half of the basal area are named for the majority species; types where no individual species comprises more than half of the basal-area stocking are named for the plurality species along with a modifier (mix) to denote the lack of a majority species (Eyre 1980).

Veg Table 10. Existing forest cover types of the Phillips/Gordon analysis area.

CODE	FOREST COVER TYPE DESCRIPTION	ACRES	PERCENT
CA	Forest with subalpine fir as the majority species	306	<1
CAmix	Mixed forest with subalpine fir as the plurality species	631	2
CD	Forest with Douglas-fir as the majority species	3,078	8
CDmix	Mixed forest with Douglas-fir as the plurality species	4,739	13
CE	Forest with Engelmann spruce as the majority species	702	2
CEmix	Mixed forest with Engelmann spruce as the plurality species	689	2
CL	Forest with lodgepole pine as the majority species	218	<1
CLmix	Mixed forest with lodgepole pine as the plurality species	174	<1
CP	Forest with ponderosa pine as the majority species	2,050	6
CPmix	Mixed forest with ponderosa pine as the plurality species	2,952	8
CT	Forest with western larch as the majority species	615	2
CTmix	Mixed forest with western larch as the plurality species	1,246	3
CW	Forest with grand fir as the majority species	10,126	28
CWmix	Mixed forest with grand fir as the plurality species	5,562	15
Other	Non-forest cover types (grass and shrub); administrative sites	3,315	9

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreage figures include National Forest System (NFS) lands only. Forest cover types where one tree species has a majority (comprising 50% or more of the stocking) are named for that species (Eyre 1980). For polygons where no single species predominates, the cover type is named for the plurality species followed by "mix" to designate a mixed-species composition.

Veg Table 11. Area (acres) of existing forest cover types by subwatershed (SWS).

SWS	Subalpine Fir	Douglas-fir	Engelmann Spruce	Lodgepole Pine	Ponderosa Pine	Western Larch	Grand Fir
7A	150	508	141	66	850	571	2,119
7B	223	501	239	121	135	198	2,465
Total	373	1,009	380	187	985	769	4,584
84B	393	1,234	277	117	866	280	1,896
84C	—	650	64	—	848	130	1,456
84D	130	889	411	64	249	65	1,875
84E	27	1,620	133	24	582	23	1,369
84H	8	421	40	—	216	197	1,387
84I	6	1,993	83	—	1,257	397	3,122
Total	564	6,807	1,008	205	4,018	1,092	11,105
Grand Total	937	7,816	1,388	392	5,003	1,861	15,689

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreage figures include NFS lands only. Veg Table 10 describes the forest cover types used as column headings in this table. Note that majority and plurality types were summed for this table (e.g., CA + CAmix = Subalpine fir).

Veg Table 12. Existing forest density classes of the Phillips/Gordon analysis area.

CODE	FOREST DENSITY CLASS DESCRIPTION	ACRES	PERCENT
Low	Live canopy cover of trees is between 10 and 40 percent	11,648	35
Moderate	Live canopy cover of trees is between 41 and 70 percent	9,189	28
High	Live canopy cover of trees is greater than 70 percent	12,249	37

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreages include NFS lands only.

Veg Table 13. Area (acres) of existing forest density classes by subwatershed (SWS).

SWS	LOW (10-40%)	MODERATE (41-70%)	HIGH (71-100%)
7A	1,447	1,359	1,599
7B	1,340	611	1,931
Total	2,787	1,970	3,530
84B	1,831	1,429	1,803
84C	945	1,287	917
84D	1,318	1,319	1,046
84E	1,972	1,051	755
84H	896	220	1,153
84I	1,899	1,913	3,045
Total	8,861	7,219	8,719
Grand Total	11,648	9,189	12,249

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreage figures include NFS lands only. Veg Table 12 describes the forest density class codes used as column headings in this table.

Forest Size Classes. The diameter (size) distribution of trees is a key element in the structure of a forest stand and hence its biological diversity. Forest structure, for example, has an important influence on songbirds and other avian species. Since the relationship between tree diameter and height is well defined, and because there is a strong positive correlation between tree height and foliage complexity, forest size classes can serve as an effective proxy for foliage (canopy) complexity (Buongiorno and others 1994). Foliage complexity and other canopy attributes are often important when estimating the effect of vegetation conditions on wildlife species.

Historically, forest size classes were defined using economically important criteria that emphasized wood product or utilization standards (small sawtimber, large sawtimber, etc.). Size class definitions recently evolved to incorporate a biological approach based on tree size or physiological maturity. The Phillips/ Gordon analysis used size class definitions that reflect tree size (note that size class was based on tree diameter rather than tree height).

Veg Tables 14 and 15 summarize the area of existing forest size classes for the Phillips and Gordon watersheds. They show that the predominant overstory size class is a mixture of small and medium trees (42% of the forested portion of the analysis area), followed by small trees ranging from 9 to 15 inches in diameter (15%), small trees ranging from 15 to 21 inches in diameter (12%), and poles and small trees mixed (12%). Forest overstories dominated by medium or large trees (those with diameters of 21 inches or more), or seedlings and saplings (trees less than 5 inches in diameter) are uncommon; each of those size classes occupies two percent or less of the forested portion of the Phillips/Gordon area. Veg Figure 8 (see appendix 2) shows forest size classes in the Phillips/Gordon area.

Veg Table 14. Existing forest size classes of the Phillips/Gordon analysis area.

CODE	FOREST SIZE CLASS DESCRIPTION	ACRES	PERCENT
1	Seedlings; trees less than 1 inch in diameter	254	<1
2	Seedlings and saplings mixed	323	1
3	Saplings; trees from 1 to 4.9 inches in diameter	679	2
4	Saplings and poles mixed	275	<1
5	Poles; trees from 5 to 8.9 inches in diameter	574	2
6	Poles and small trees mixed	4,181	12
6.5	Small trees from 9 to 14.9 inches in diameter	4,980	15
7	Small trees from 9 to 20.9 inches in diameter	3,278	10
7.5	Small trees from 15 to 20.9 inches in diameter	3,884	12
8	Small trees and medium trees mixed	13,715	42
9	Medium trees from 21 to 31.9 inches in diameter	762	2
10	Medium and large trees mixed	120	<1
12	Large and giant trees mixed	62	<1

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreage figures include NFS lands only. Forest size classes are based on the predominant situation and are seldom pure – the pole size class (5) has a predominance of pole-sized trees (50% or more) but may also contain minor amounts of other size classes. For multi-layered stands, this information pertains to the overstory layer only.

Veg Table 15. Area (acres) of existing forest size classes by subwatershed (SWS).

	FOREST SIZE CLASS CODE FOR OVERSTORY TREE LAYER												
SWS	**1**	**2**	**3**	**4**	**5**	**6**	**6.5**	**7**	**7.5**	**8**	**9**	**10**	**12**
7A	16	46	105	47	182	447	618	263	871	1,598	213	—	—
7B	—	56	142	16	22	788	854	337	626	934	108	—	—
Total	16	102	247	63	204	1,235	1,472	600	1,497	2,532	321	—	—
84B	19	63	96	—	183	744	946	544	680	1,703	38	48	—
84C	—	—	74	48	20	112	919	191	458	1,204	62	—	62
84D	95	64	128	11	66	499	436	804	489	916	138	37	—
84E	95	92	50	128	95	747	241	565	227	1,460	43	35	—
84H	—	—	—	7	—	37	22	—	60	2,081	64	—	—
84I	29	2	85	18	7	807	943	577	473	3,819	97	—	—
Total	238	221	433	212	371	2,946	3,507	2,681	2,387	11,183	442	120	62
Grand Total	254	323	680	275	575	4,181	4,979	3,281	3,884	13,715	763	120	62

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreage figures include NFS lands only. Veg Table 14 describes the size class codes used as column headings in this table.

Forest Structural Classes. As a forest matures, it experiences successive and predictable changes in its structure. It may begin as a young, single-layer forest, but does not stay in that stage forever and eventually occupies other stages as part of a normal maturation (successional) process. In recent classification systems, structural entities have been referred to as "classes" rather than "stages" because it is not always appropriate to assume a sequential progression from one entity to another (O'Hara and others 1996).

One of the first efforts to classify forest development in the Interior Northwest was Thomas's (1979) system for the Blue Mountains of Oregon and Washington. His stages characterized the sequential development of stands following clearcutting and, barring additional disturbance, involved a six-step progression: seedlings and saplings, saplings and poles, poles, small sawtimber, large sawtimber, and old growth.

Since publication of Thomas's classification, other structural approaches have been developed. Recently, a series of four process-based development stages was published by Oliver and Larson (1996). Although Oliver and Larson's (1996) classification works well for the geographical area in which it was developed (coniferous forests located west of the Cascade Mountains in Oregon and Washington), certain forest conditions in the Interior Northwest do not fit their four-stage approach. Consequently, their system was expanded to 7 classes to include a wider spectrum of structural variation; the Phillips/Gordon analysis used this 7-class system (O'Hara and others 1996).

Veg Tables 16 and 17 summarize the area of forest structural classes for the Phillips and Gordon watersheds. They show that the predominant structural stage is stem exclusion open canopy (25% of the analysis area), followed by young forest multi strata (23%), old forest multi strata (18%), and stand initiation (13%). Old forest single stratum, understory reinitiation, and stem exclusion closed canopy are relatively uncommon structural classes – each of them occupies less than 10 percent of the analysis area. Veg Figure 9 (appendix 2) shows forest structural classes in the Phillips/Gordon area.

Veg Table 16. Existing forest structural classes of the Phillips/Gordon analysis area.

CODE	FOREST STRUCTURAL CLASS DESCRIPTION	ACRES	PERCENT
OFMS	Old Forest Multi Strata structural class	5,898	18
OFSS	Old Forest Single Stratum structural class	2,657	8
SECC	Stem Exclusion Closed Canopy structural class	1,334	4
SEOC	Stem Exclusion Open Canopy structural class	8,264	25
SI	Stand Initiation structural class	4,378	13
UR	Understory Reinitiation structural class	2,893	9
YFMS	Young Forest Multi Strata structural class	7,663	23

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreage figures include NFS lands only. Forest structural classes are described in Powell 2000 (see table 2, page 16).

Forest Canopy Layers. The vertical arrangement of tree canopy has an important influence on resource issues and values. For example, multi-layered stands with "old-growth" characteristics (e.g., a predominance of grand fir trees, high canopy closure, and an absence of logging evidence) are highly valued by pileated woodpeckers in the Blue Mountains (Bull and Holthausen 1993). Open, single-layered structures may have limited value for water quality, but high desirability for water yields (O'Hara and Oliver 1992).

Veg Tables 18 and 19 summarize the area of existing forest canopy layers for the Phillips and Gordon watersheds. They show that the predominant situation is a highly-complex layer structure (3 or more layers; 50% of the forested portion of the analysis area), followed by a two-layer stand structure (41% of the forested area) and single-layer forest (9%).

Veg Table 17. Area (acres) of existing forest structural classes by subwatershed (SWS).

	FOREST STRUCTURAL CLASS CODE

SWS	SI	SEOC	SECC	UR	YFMS	OFMS	OFSS
7A	603	754	140	532	980	897	498
7B	687	712	93	612	835	850	93
Total	1,290	1,466	233	1,144	1,815	1,747	591
84B	768	1,385	22	671	1,162	720	335
84C	218	1,206	126	195	1,199	205	—
84D	872	810	305	381	435	383	497
84E	603	1,412	257	203	627	406	271
84H	50	727	9	82	189	756	457
84I	577	1,258	382	217	2,235	1,680	507
Total	3,088	6,798	1,101	1,749	5,847	4,150	2,067
Grand Total	4,378	8,264	1,334	2,893	7,662	5,897	2,658

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Veg Table 16 describes the structural class codes used as column headings. Acreages include NFS lands only.

Veg Table 18. Existing forest canopy layers of the Phillips/Gordon analysis area.

CODE	FOREST CANOPY LAYER DESCRIPTION	ACRES	PERCENT
1	Live canopy (crown) cover of trees occurs in l layer (stratum)	3,168	9
2	Live canopy cover of trees occurs in 2 layers or strata	13,557	41
3	Live canopy cover of trees occurs in 3 or more layers or strata	16,362	50

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreages include NFS lands only.

Veg Table 19. Area (acres) of existing forest canopy layers by subwatershed (SWS).

SWS	SINGLE LAYER	TWO LAYER	THREE LAYER
7A	177	1,982	2,245
7B	478	1,504	1,899
Total	655	3,486	4,144
84B	355	1,548	3,160
84C	20	799	2,331
84D	840	1,351	1,493
84E	679	1,922	1,177
84H	120	1,020	1,130
84I	500	3,430	2,927
Total	2,514	10,070	12,218
Grand Total	3,169	13,556	16,362

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Acreages include NFS lands only. Veg Table 18 describes the canopy layer codes used as column headings.

REFERENCE CONDITIONS

Forest Cover Types. Historically, forest cover types were named for an economically important species such as ponderosa pine that might be present at a fairly low level of abundance, thus ignoring a more abundant but less valuable species. Therefore, the historical forest type maps used to characterize reference conditions may contain inherent biases related to the commercial value of certain species.

Veg Table 20 summarizes vegetation conditions as they existed in 1900 (Gannett 1902); however, it is not possible to make direct comparisons between the 1900 and later maps because of differences in their resolution and due to widely-divergent map legends. The 1900 map shows that 60% of the Phillips/Gordon analysis area consisted of moderate-density forest. Low- and high-density forest comprised 10% and 12% of the area, respectively. Burnt, timberless, and woodland types comprised 18% of the analysis area. Veg Figure 10 (see appendix 2) shows the geographical distribution of vegetation conditions in 1900.

Veg Table 20. Vegetation conditions in the Phillips/Gordon analysis area as of 1900.

MAP ATTRIBUTE	INFERRED VEGETATION CONDITIONS	AREA (ACRES)	PER-CENT
Timberless	Nonforest areas dominated by grasses or shrubs	16,314	14%
Woodland	Widely scattered ponderosa pine (savannah forest)	1,018	1%
0–5 MBF/Acre	Low-density forest of pure or mixed composition	11,394	10%
5–10 MBF/Acre	Moderate-density forest of pure or mixed composition	67,765	60%
10–25 MBF/Acre	High-density forest of pure or mixed composition	13,277	12%
Burnt	Areas burned by wildfire	2,844	3%

Sources/Notes: From a “Map of the state of Oregon showing the classification of lands and forests; prepared by Gilbert Thompson from information obtained by A.J. Johnson.” The map (dated 1900) was included in the back pocket, as plate I, of a report by Gannett (1902). Inferred vegetation conditions were supplied by the author of this report, not by Gannett. Acreages include all land ownerships in the analysis area.

Veg Table 21 summarizes the area of historical forest cover types for the Phillips and Gordon watersheds. It shows that the predominant forest cover type in 1936 was grand fir (42% of the forested portion of the analysis area), followed by ponderosa pine (26%) and a mixed composition (24%). In 1958, the predominant forest type was grand fir (45% of the classified, forested area), followed by ponderosa pine (22%), Douglas-fir (20%), and western larch (7%). Veg Figure 11 (appendix 2) shows the geographical distribution of forest cover types in 1936.

Forest Density Classes. Veg Table 22 summarizes the area of historical forest density classes for the Phillips and Gordon watersheds. It shows that the predominant situation in 1936 was high-density forest (>70% canopy cover; 77% of the classified portion of the analysis area), followed by low density (10-40% cover; 16% of classified area) and moderate density (41-70% cover; 7%). In 1958, the predominant density class was high (74% of the classified area), followed by moderate (17%) and low (10%).

Forest Size Classes. Veg Table 23 summarizes the area of historical forest size classes for the Phillips and Gordon watersheds. It shows that the predominant overstory size class in 1936 was a mixture of small and medium trees ranging from 9 to 32 inches in diameter (56% of the classified portion of the analysis area), followed by medium trees (21 to 32 inches DBH; 26%) and then a mix of saplings and poles ranging from 1 to 9 inches in diameter (15%). In 1958, the predominant size class was a mix of medium and large trees ranging from 21 to 48 inches in diameter (65% of the classified area), followed by small trees ranging from 15 to 21 inches in diameter (29%).

Veg Table 21. Historical forest cover types of the Phillips/Gordon analysis area (acres).

CODE	FOREST COVER TYPE DESCRIPTION	1936	1958
BU	Burns at time of survey (no forest cover type provided)	73	—
CA	Forests with a predominance of subalpine fir trees	550	849
CD	Forests with a predominance of Douglas-fir trees	482	6,907
CE	Forests with a predominance of Engelmann spruce trees	—	485
CL	Forests with a predominance of lodgepole pine trees	784	966
CP	Forests with a predominance of ponderosa pine trees	9,876	7,366
CT	Forests with a predominance of western larch trees	1,448	2,375
CW	Forests with a predominance of grand fir trees	16,076	15,289
Mix	Mixed forests; less than 50% of one species	9,082	—
NF	Non-forest cover types	1,480	4,488
Unknown	Unclassified	185	1,320

Sources/Notes: Summarized from the 1936veg and 1958veg databases (see appendix 1). Acreages include NFS lands only (including those administered by the Wallowa-Whitman NF).

Veg Table 22. Historical forest density classes of the Phillips/Gordon analysis area (acres).

CODE	FOREST DENSITY CLASS DESCRIPTION	1936	1958
Low	Live canopy cover of trees is between 10 and 40 percent	973	1,578
Moderate	Live canopy cover of trees is between 41 and 70 percent	445	2,756
High	Live canopy cover of trees is greater than 70 percent	4,844	12,177
Unknown	Unclassified and non-forest cover types	33,775	23,535

Sources/Notes: Summarized from the 1936veg and 1958veg databases (see appendix 1). Acreages include NFS lands only (including those administered by the Wallowa-Whitman NF).

Veg Table 23. Historical forest size classes of the Phillips/Gordon analysis area (acres).

CODE	FOREST SIZE CLASS DESCRIPTION	1936	1958
2	Seedlings and saplings mixed	396	93
4	Saplings and poles mixed	5,709	—
6	Poles and small trees mixed	388	1,959
7.5	Small trees from 15 to 20.9 inches in diameter	301	10,049
8	Small trees and medium trees mixed	21,007	—
9	Medium trees from 21 to 31.9 inches in diameter	9,947	—
10	Medium and large trees mixed	—	22,137
Unknown	Unclassified and non-forest cover types	2,288	5,807

Sources/Notes: Summarized from the 1936veg and 1958veg databases (see appendix 1). Acreages include NFS lands only (including those administered by the Wallowa-Whitman NF). For multi-layered stands, this information pertains to the overstory layer only.

Forest Structural Classes. Veg Table 24 summarizes the area of historical forest structural classes for the Phillips and Gordon watersheds. It shows that the predominant structural class in 1936 was old forest multi strata (56% of the classified, forested area), followed by old forest single stratum (25%) and stem exclusion closed canopy (13%). The other four structural classes were uncommon – each of them occupied two percent or less of the forested portion of the analysis area. In 1958, the predominant structural class was old forest multi strata (52% of the classified, forested area), followed by understory reinitiation (17%) and old forest single stratum (16%). Veg Figure 12 (appendix 2) shows forest structural classes for the Phillips and Gordon watersheds as of 1936.

Veg Table 24. Historical forest structural classes of the Phillips/Gordon analysis area (acres).

CODE	FOREST STRUCTURAL CLASS DESCRIPTION	1936	1958
OFMS	Old Forest Multi Strata structural class	21,623	17,754
OFSS	Old Forest Single Stratum structural class	9,465	5,584
SECC	Stem Exclusion Closed Canopy structural class	5,140	1,726
SEOC	Stem Exclusion Open Canopy structural class	562	233
SI	Stand Initiation structural class	864	93
UR	Understory Reinitiation structural class	416	5,870
YFMS	Young Forest Multi Strata structural class	301	2,978
NF	Non-forest cover types	1,480	4,488
Unknown	Unclassified	185	1,320

Sources/Notes: Summarized from the 1936veg and 1958veg databases (see appendix 1). Acreages include NFS lands only (including those administered by the Wallowa-Whitman NF).

Forest Canopy Layers. Veg Table 25 summarizes the area of historical forest canopy layers for the Phillips/Gordon analysis area. It shows that the predominant situation in 1936 was an even-aged, single-layer condition (91% of the classified area), followed by an uneven-aged, multi-layer situation (9%). In 1936, note that most of the watershed area was unclassified for this analysis indicator. Unfortunately, the 1958 forest type map did not provide any information for the canopy layer analysis indicator.

Veg Table 25. Historical forest canopy layers of the Phillips/Gordon analysis area (acres).

CODE	FOREST CANOPY LAYER DESCRIPTION	1936	1958
EA	Live canopy cover of trees occurs in l layer (stratum)	5,050	No Data Available
UA	Live canopy cover of trees occurs in 2 or more layers or strata	474	
Unknown	Unclassified and non-forest cover types	34,512	

Sources/Notes: Summarized from the 1936veg database (see appendix 1). Acreages include NFS lands only (including those administered by the Wallowa-Whitman NF).

SYNTHESIS AND INTERPRETATION

Forest Cover Types. Forest composition has been relatively stable in the analysis area over the last 65 years (Veg Tables 10 and 21). The predominant forest cover type in 1936, 1958, and currently is grand fir; it comprised between 42 and 45 percent of the area during that time span. In 1936 and 1958, ponderosa pine was the second most common cover type, comprising 26 and 22 percent of the analysis area, respectively. At the present time, only 14% of the analysis area has a plurality or majority of ponderosa pine. Douglas-fir cover types comprised 20 percent of the analysis area in 1958 and 21 percent currently.

Recent bioregional assessments concluded that dry-forest areas have vegetation conditions that are out-of-balance when compared with the historical (presettlement) situation (Caraher and others 1992, Hessburg and others 1999, Lehmkuhl and others 1994, Quigley and Arbelbide 1997). Further analysis of forest cover types corroborates that finding and suggests that too many dry-forest sites in the analysis area currently support grand fir or Douglas-fir forest. In the presettlement era, it is believed that dry forests would have supported 72-90% ponderosa pine, 8-14% Douglas-fir, and 1-5% grand fir (Morgan and Parsons 2000). Currently, dry-forest sites support 22% ponderosa pine, 49% Douglas-fir, and 24% grand fir.

Forest Density Classes. A comparison of current and reference conditions (Veg Tables 12 and 22) indicates that the percentage of high-density forest may have declined substantially over the last 65 years. However, such a comparison is misleading because a very high proportion of the analysis area was not rated for this analysis indicator in both 1936 (84%) and 1958 (59%). If it is assumed that much of the non-rated portion of the analysis area consisted of an open forest (low-density) condition, then the current proportion of high-density forest (37%) would be as great as, if not greater than, it was historically.

Recently-developed stocking guidelines (Cochran and others 1994, Powell 1999) were used to analyze existing forest density levels to infer whether they are ecologically sustainable. By using the stocking guidelines in conjunction with potential vegetation (plant association groups), it was possible to determine the acres that would be considered overstocked. Overstocked forests have density levels in the “self thinning” zone where trees aggressively compete with each other for moisture, sunlight, and nutrients. Forests in the self-thinning zone experience mortality as crowded trees die from competition or from insects or diseases that attack trees under stress (Powell 1999).

A forest density analysis was used to help identify treatment opportunities; it was completed using the following process.

a. Since canopy cover was the only data item that could serve as a surrogate for forest density, equations were used to convert the stand density index information from Cochran and others (1994) into basal areas, and then from basal area into canopy cover (see Powell 1999 for the resultant canopy cover percentages).

b. Moist sites are capable of sustaining higher forest densities than dry sites, so potential vegetation (as represented by plant association groups) was used to stratify the watershed into classes with similar ecological capability to support forest density.

c. An analysis of forest density is species dependent, but it would be cumbersome to evaluate stocking for every tree species that could occur in each PAG. Since early-seral tree species are much more sensitive to dense, overcrowded conditions than late-seral species (Powell 2000, fig. 16), an early-seral species was selected to represent each PAG. Veg Table 26 shows the selected tree species.

d. It was then possible to directly compare total canopy cover from the ExistPG database and the recommended stocking levels expressed as canopy cover. The results of this comparison are summarized in Veg Table 27; it shows the acreage of each PAG that would be considered overstocked if the objective is to maintain density levels compatible with survival of the early-seral tree species.

Veg Table 26. Early-seral tree species and canopy cover values selected for the forest density analysis.

UPLAND FOREST PLANT ASSOCIATION GROUP	EARLY-SERAL SPECIES	LLMZ CANOPY COVER	ULMZ CANOPY COVER	SELECTED COVER VALUE
Cool Wet (CW)	ES	76	83	80
Cool Very Moist (CVM)	ES	77	85	80
Cold Dry (CD)	LP	59	66	65
Cool Moist (CM)	WL	64	71	65
Warm Very Moist (WVM)	WL	63	70	65
Warm Moist (WM)	WL	65	73	65
Warm Dry (WD)	PP	43	51	45
Hot Dry (HD)	PP	26	33	30

Sources/Notes: Plant association groups are described in Powell (1998) and in Veg Table 4. "Early-seral species" codes are: ES, Engelmann spruce; LP, lodgepole pine; WL, western larch; and PP, ponderosa pine. The "LLMZ Canopy Cover" and "ULMZ Canopy Cover" values are the mean canopy cover percentages associated with the lower limit of the management zone and the upper limit of the management zone stocking levels, respectively, for the early-seral species/ PAG combination specified in the first two columns (ULMZ and LLMZ are defined in Powell 1999). The "Selected Cover Value" is the canopy cover percentage used for the density analysis.

Veg Table 27. Forest density analysis for the Phillips/Gordon analysis area.

PAG	AREA (NFS Acres) BY CANOPY COVER					TOTAL ACRES	OVER-STOCKED
	10-29%	30-45%	46-65%	66-80%	>80%		
CW	0	98	455	230	589	1,372	589
CVM	0	0	51	0	0	51	0
CD	171	129	147	116	157	720	273
CM	2,054	2,706	3,765	2,860	5,336	16,721	8,196
WVM	38	65	104	250	1,614	2,071	1,864
WM	676	301	430	325	428	2,160	753
WD	5,149	1,445	1,434	1,360	304	9,692	3,098
HD	196	10	56	36	0	298	102
Total	8,284	4,754	6,442	5,177	8,428	33,085	14,875

Sources/Notes: A forest density analysis was based on five categories of canopy cover and the upland-forest PAGs. The black cells indicate the National Forest System acreage that is presently overstocked if the objective is to maintain healthy forests with a component of early-seral species. Veg Table 26 provides PAG abbreviations and the early-seral species selected for each PAG.

Forest Size Classes. As was the case with forest cover types, overstory size classes have been relatively stable over the last 65 years (Veg Tables 14 and 23). A mix of small and medium trees (9 to 32 inches in diameter) was the predominant size class in both 1936 and currently, comprising 56% of the area in 1936 and 69% now. In 1958, it was much the same situation except that the range of tree sizes was larger – 94% of the forested area was comprised of trees ranging from 15 to 48 inches in diameter.

One of the implications of this trend in size classes is that there is less area dominated by very small trees now than there was historically. In 1936, forests dominated by seedlings, saplings, or poles comprised about 16% of the classified portion of the analysis area; currently, only 4% of the Phillips/Gordon area supports those same size classes.

This reduction in the small size classes is probably due to a variety of factors, including differences in resolution between the historical and current data sources (the historical map was compiled using ground reconnaissance; the current map is a product of stand exams and photo-interpretation data); plant succession (immature forest in 1936 is now mature forest 65 years later); and disturbance processes (the 1936 map may have depicted young, regenerating forests resulting from wildfires or early timber harvests).

Forest Structural Classes. A comparison of historical and current structural classes shows that the analysis area was dominated by old forest classes in 1936, with very little of any other class except stem exclusion (Veg Tables 16 and 24). By 1958, old forest was still predominant although other classes were better represented than in 1936, as evidenced by increases in understory reinitiation and young forest multi strata. Currently, stem exclusion is the predominant structural class (29%), followed by old forest (26%) and young forest multi strata (23%). Regenerating forest (stand initiation; 13%) is more prevalent now than it was historically.

The implications of this trend in structural classes is that old forest structures are less common now than they were historically; that regenerating forest (stand initiation) is more prevalent now than it was historically; and that mid-seral structural classes (understory reinitiation, stem exclusion, and young forest multi strata) are more abundant now than they were historically.

To understand the implications of current conditions, it is often helpful to put them in an historical context. A technique was recently developed to help put current conditions in their historical context – the historical range of variability (HRV).

Managers often consider HRV to be an indicator of ecological sustainability – historical conditions are believed to represent sustainable conditions, at least to whatever extent Nature emphasized sustainability. A key premise of HRV is that native species are adapted to, and have evolved with, the prevailing disturbance regime of an area. For that reason, ecosystem elements occurring within their historical range are believed to represent resilient and healthy situations (Morgan and others 1994, Swanson and others 1994).

Although HRV can be applied to a wide variety of ecosystem elements, it was decided to use it with structural classes. Structural classes are inclusive – any particular point on a forest's developmental pathway can be assigned to a structural class. They are also universal – every forest eventually passes through a series of structural classes, although not every stand occupies every class or spends an equal amount of time in any particular class. For those reasons – inclusiveness and universality – structural classes provide a valuable framework for comparing current and reference conditions.

An HRV analysis was completed for the Phillips/Gordon analysis area. It was based on two primary factors – forest structural classes and potential vegetation (as represented by PAGs). Results of the HRV analysis are provided in Veg Table 28. It summarizes the current percentage of each structural class, by plant association group; the historical ranges for each of the structural classes are also shown.

Perusing the HRV results in Veg Table 28 shows that the young forest multi strata and stem exclusion closed canopy structural classes are below their historical ranges for three plant association groups (PAGs), and that the old forest single stratum and stem exclusion open canopy structural classes are above their historical ranges for five or four PAGs, respectively. Note that HRV was not interpreted for the cool very moist or hot dry PAGs due to their limited acreage within the analysis area.

Veg Table 28. Historical range of variability (HRV) analysis for forest structural classes.

PAG		SI	SEOC	SECC	UR	YFMS	OFMS	OFSS	NFS ACRES
		FOREST STRUCTURAL CLASSES							
CW	H%	1-10	0-5	1-10	5-25	20-50	30-60	0-5	1,372
	C%	6	3	1	7	47	28	**8**	
CVM	H%	1-10	0-5	5-20	5-25	20-60	20-40	0-5	51*
	C%	0	100	0	0	0	0	0	
CD	H%	1-20	0-5	5-20	5-25	10-40	10-40	0-5	721
	C%	11	**25**	3	**1**	14	19	**29**	
CM	H%	1-10	0-5	5-25	5-25	40-60	10-30	0-5	16,722
	C%	12	**17**	**2**	11	**34**	15	**9**	
WVM	H%	1-15	0-5	5-20	5-20	20-50	20-40	0-5	2,070
	C%	5	0	**0**	17	**8**	**44**	**26**	
WM	H%	1-15	0-5	5-20	5-20	20-50	10-30	0-5	2,160
	C%	**21**	**26**	**0**	4	**12**	26	**12**	
WD	H%	5-15	5-20	1-10	1-10	5-25	5-20	15-55	9,692
	C%	17	**46**	10	5	8	14	**0**	
HD	H%	5-15	5-20	0-5	0-5	5-10	5-15	20-70	298*
	C%	18	47	34	0	0	0	0	

Sources/Notes: Summarized from the ExistPG database (see appendix 1). Upland forest plant association groups (PAG) are described in Powell (1998) and in Veg Table 4. Historical percentages (H%) were derived from Hall (1993), Johnson (1993), and USDA Forest Service (1995a), as summarized in Blackwood (1998). Current percentages (C%) were based on NFS lands (Umatilla NF only). Structural class codes are described in appendix 1 and in Veg Table 16. Gray cells show instances where the current percentage (C%) is above the historical percentage (H%) for a structural class. Black cells show instances where the current percentage is below the historical percentage. Since an HRV analysis is somewhat imprecise, deviations (whether above or below the H% range) were only noted when the current percentage differed from the historical range by 2 percent or more.
* Note that deviations from the historical range (either above or below) were not shown for the cool very moist and hot dry PAGs due to their limited area within the Phillips/Gordon analysis area.

Forest Canopy Layers. A comparison of current and reference conditions with respect to forest canopy layers (Veg Tables 18 and 25) shows that the analysis area was dominated historically by single-layer forest, whereas the modern forest tends to have two or more layers. This comparison is very misleading, however, because a very high proportion of the Phillips and Gordon watersheds (86%) was not rated for this analysis indicator in 1936. Canopy layer information was not provided by the 1958 forest type map.

Further analysis of forest canopy layers shows that 85% of dry-forest sites in the analysis area currently have a multi-layered structure. This situation is inconsistent with the historical situation because it is believed that dry forests had a very high percentage of single-layer structure in the presettlement era, with perhaps as much as 70% of the ponderosa pine forest occurring as that structure (see OFSS historical range for the "hot dry" plant association group in Veg Table 28 above).

Forest Insects and Diseases (Risk). This upland-forest analysis is focused primarily on one issue: forest sustainability (see page 5). One factor influencing forest sustainability is tree damage or death caused by insects and diseases, many of which respond directly to forest composition, structure, or density (e.g., their host-type habitat). Forest inventory plots from the analysis area were used to characterize insect and disease risk; risk-rating results for nine important insects and diseases are provided in Veg Table 29.

Veg Table 29 shows that high risk (susceptibility) is present for western spruce budworm, and that the analysis area has moderate to high risk for Douglas-fir tussock moth and Douglas-fir beetle. Spruce beetle has low to moderate risk. All other insect or disease agents (Douglas-fir dwarf mistletoe, mountain pine beetle in lodgepole pine, mountain pine beetle in ponderosa pine, mixed conifer root diseases, and white pine blister rust) were rated low for the Phillips/Gordon analysis area.

It is interesting that Douglas-fir tussock moth susceptibility was rated as moderate to high. Each spring, pheromone traps are placed in mixed-conifer stands throughout the Umatilla National Forest as an early-warning system for Douglas-fir tussock moth. Beginning in 1998, this early-warning system indicated that the northern Blue Mountains were facing an imminent outbreak. An outbreak actually began in the spring of 2000 and 39,392 acres on the Pine, Pomeroy, and Walla Walla Ranger Districts were sprayed with TM-BioControl, a natural virus affecting tussock moth only, during June and July of 2000 to minimize tussock-moth damage in specific areas of concern (old-growth stands, bull-trout habitat, etc.). It is anticipated that tussock-moth defoliation will continue for several more years before subsiding.

Veg Table 29. Insect and disease risk ratings for the Phillips/Gordon analysis area.

INSECT OR DISEASE	RISK RATING	CABIN-GORDON	PHILLIPS-WILLOW
Douglas-fir Beetle	Low	65%	47%
	Moderate	14%	24%
	High	21%	29%
Douglas-fir Dwarf Mistletoe	Low	96%	96%
	Moderate	0%	4%
	High	4%	0%
Mountain Pine Beetle (Lodgepole Pine)	Low	93%	100%
	Moderate	4%	0%
	High	3%	0%
Mountain Pine Beetle (Ponderosa Pine)	Low	93%	99%
	Moderate	0%	0%
	High	7%	1%
Mixed Conifer Root Diseases	Low	89%	93%
	Moderate	0%	0%
	High	11%	7%
Spruce Beetle	Low	61%	78%
	Moderate	32%	22%
	High	7%	0%
Western Spruce Budworm	Low	32%	7%
	Moderate	7%	0%
	High	61%	93%
Douglas-fir Tussock Moth	Low	39%	16%
	Moderate	39%	51%
	High	22%	33%
White Pine Blister Rust	Low	100%	100%
	Moderate	0%	0%
	High	0%	0%

Sources/Notes: Calculations based on Current Vegetation Survey inventory plots located within the Phillips/Gordon analysis area (Ager 2000).

Assessment of Forest Sustainability. The health and sustainability of forest ecosystems is an issue, not just in the United States but around the World (Heissenbuttel and others No date). A protocol was recently established for evaluating forest sustainability at a national or international scale, including a set of criteria and indicators (Montreal Process 1995). In an effort to develop an assessment protocol that could be used at smaller scales, a landscape-level methodology was recently developed (Amaranthus 1997). It was based on four criteria originally proposed in 1994 (Kolb and others 1994). The four criteria, and an assessment of how the Phillips/Gordon watershed rates with respect to each of them, are provided below.

1. **The physical environment, biotic resources, and trophic networks to support productive forests**. Over most of the Phillips and Gordon watersheds, the physical, biotic, and trophic networks are intact to support fully functioning forest ecosystems. There may be exceptions at the sub-stand level where previous management practices resulted in compacted soils, aggraded stream reaches, or similar impacts. Such areas are limited, however, and forests of the Phillips/Gordon analysis area are probably in a sustainable condition when evaluated using this criterion.

2. **Resistance to catastrophic change and the ability to recover on the landscape level**.
A significant threat of stand-replacing disturbance exists within the Phillips and Gordon watersheds that could dramatically alter plant and animal structure and composition. This threat is a direct result of an altered disturbance regime and is related primarily to 90 years or more of fire suppression. It is likely that dry-forest sites in the analysis area have missed two to five fire cycles, contributing to unnaturally-high fuel accumulations. Under the recent fire regime (suppression), the influence of fire as an ecological process has been markedly reduced – resulting in more homogenous landscape patterns with fewer vegetation types (particularly early-seral stages), larger patches at lower patch densities, and less total edge than would have been produced by the historical fire regime. Outbreaks of defoliators and other landscape-scale insects, and propagation of active or independent crown fire, can be expected in response to this increased level of homogeneity. Based on this second criterion, forests of the Phillips/Gordon analysis area are probably not in a sustainable condition.

3. **A functional equilibrium between supply and demand of essential resources**.
Forty-five percent of the Phillips/Gordon analysis area has tree density levels that threaten future sustainability of upland forests. Nutrient cycling and the availability of water and growing space is undoubtedly impaired on these overstocked sites. In addition, these dense stands represent high susceptibility to crown fire. The primary factor controlling crown fire behavior is crown bulk density (the volume of tree crowns or canopy available for fire consumption), and crown bulk density is directly dependent upon species composition and stand density. Dense stands are not only more likely to initiate crown fire behavior, but also to sustain an active (running) crown fire once it begins. Based on this criterion, forests of the Phillips/Gordon analysis area may be sustainable, but only marginally.

4. **A diversity of seral stages and stand structures that provide habitat for any native species and all essential ecosystem processes**.
The Phillips and Gordon watersheds support a relatively well-balanced distribution of seral stages and stand structures (as indicated by the historical range of variability analysis for forest structural classes). Historical forest management practices, however, have resulted in substantial changes in the spatial pattern of vegetation diversity and complexity, particularly on dry-forest sites where overcrowded, multi-strata forests were a rare phenomenon before the onset of anthropogenic fire suppression. These changes have resulted in forests at risk because they contain too many trees, or too many of the "wrong" kind of trees, to continue to thrive. As these forests get older and denser, the competition between trees intensifies, stress increases, resilience and vigor declines, and the probability of significant ("catastrophic") change goes up dramatically. Based on this fourth criterion, forests of the Phillips/Gordon analysis area are marginally sustainable right now but if recent trends in forest density and fire suppression continue unabated into the future, it is likely that forest sustainability will not be maintained over the long term.

RECOMMENDATIONS

The "recommendations" step is the final one in the "ecosystem analysis at the watershed scale" process (REO 1995). Recommendations are designed to respond to issues, concerns and findings identified during the five previous ecosystem analysis steps. Issues and concerns, and silvicultural practices that could be implemented in response to them, are summarized below.

1. High levels of forest damage occurred in the Phillips/Gordon analysis area during the late 1980s and the early 1990s (see Veg Table 7). Upland forest silvicultural practices that could be used to respond to this issue are:
   - Salvage of dead trees;
   - Planting.

2. Forty-five percent of the analysis area has forest density levels that threaten future sustainability of upland forests in the analysis area (see Veg Table 27). Upland forest silvicultural practices that could be used to respond to this issue are:
   - Thinning.

3. Substantial reductions in the area of early-seral species (particularly the ponderosa pine forest cover type) have occurred in the Phillips and Gordon watersheds between 1936 and now. Upland forest silvicultural practices that could be used to respond to this issue are:
   - Improvement cutting in stands where the early-seral species still exist;
   - Forest regeneration on dry-forest sites where early-seral species no longer exist.

4. Several analysis indicators show that dry forest sites currently have conditions that are inconsistent with ecosystem sustainability and resilience (see "forest cover types" and "forest canopy layers" discussions in the synthesis and interpretation section). Upland forest silvicultural practices that could be used to respond to this issue are:
   - Understory removal/thinning;
   - Pruning;
   - Prescribed fire.

Treatment recommendations did not explicitly consider project feasibility (logging operability, etc.), so they basically represent management opportunities. *It must be emphasized that these recommendations pertain to upland forest sites only (not to Riparian Habitat Conservation Areas).* Each of the nine treatment opportunities (silvicultural practices) listed above will be described individually.

Salvage of Dead Trees. Trees die when they cannot acquire or mobilize sufficient resources to heal injuries or otherwise sustain life (Waring 1987). In areas with a substantial number of dead trees, some of them may be salvaged. As is often the case with forest management activities, salvage logging can have both positive and negative effects. Some important benefits of salvage are to harvest and utilize wood fiber while it is still merchantable, to remove enough dead trees to promote regeneration of shade-intolerant, early-seral species, and to reduce fuel accumulations to the point where wildfire risk is acceptable and a prescribed burning program could be initiated (Powell 1994).

Any salvage removals should be done carefully. Enough dead trees should be left to provide adequate habitat for cavity-dependent birds. Retaining dead trees also provides habitat for ants and other invertebrates that prey on the larvae of defoliating insects. And standing dead trees eventually fall to the ground, where they contribute to nutrient cycling, long-term site productivity, and mycorrhizal habitat. In particular, more of the brown-rot species (pines, Douglas-fir, western larch) should be retained on-site than the white-rot species (true firs and Engelmann spruce) because their downed logs are most effective at providing long-term mycorrhizal habitat and soil moisture storage.

I recommend that salvage cutting be considered for areas with substantial amounts of forest damage; Veg Table 7 summarizes forest damage acreages by year. A salvage program should emphasize dry-forest areas because they have experienced the most pronounced changes in both species composition and forest structure over the last 90 years.

Salvage logging could also help generate revenue (K-V funds) to finance tree planting, noncommercial thinning, and other restoration treatments, but only if the dead trees are removed promptly while they still have economic value. Veg Table 30 shows the management areas in which the Umatilla National Forest Plan allows salvage cutting and associated tree planting to occur.

Veg Table 30. Management direction summary for the Phillips/Gordon analysis area.

MANAGEMENT AREA ALLOCATION	SALVAGE PERMITTED?	SUITABLE LANDS?	PLANT USING NFFV FUNDS?	PERCENT OF AREA
A3: Viewshed 1	Yes	Yes	Yes	7
A4: Viewshed 2	Yes	Yes	Yes	3
A5: Roaded Natural	Yes	Yes	Yes	11
A9: Special Interest Areas	Yes	No	No♦	<1
C1: Dedicated Old Growth	Yes*	No	No♦	3
C3: Big Game Winter Range	Yes	Yes	Yes	3
C4: Wildlife Habitat	Yes	Yes	Yes	32
C5: Riparian (Fish and Wildlife)	Yes	Yes	Yes	4
E2: Timber and Big Game	Yes	Yes	Yes	38
F3: High Ridge Evaluation Area	Yes	No	No♦	<1
PACFISH (Riparian Mgmt. Areas)	Yes	No	No♦	N.A.

Sources/Notes: Management area allocations are from the Umatilla NF Forest Plan (USDA Forest Service 1990). The "salvage permitted?" item shows whether salvage timber harvests are allowed by the management direction (standards and guidelines) for each land allocation; the "suitable lands?" item shows whether capable forested lands in the management area are designated as suitable (for timber production) by the Forest Plan; the "plant using NFFV funds" shows whether denuded or understocked lands could be planted using appropriated forest vegetation funds (NFFV); and the "percent of area" item shows the percentage of NFS lands in the analysis area allocated to the management emphasis. N.A. is not applicable.

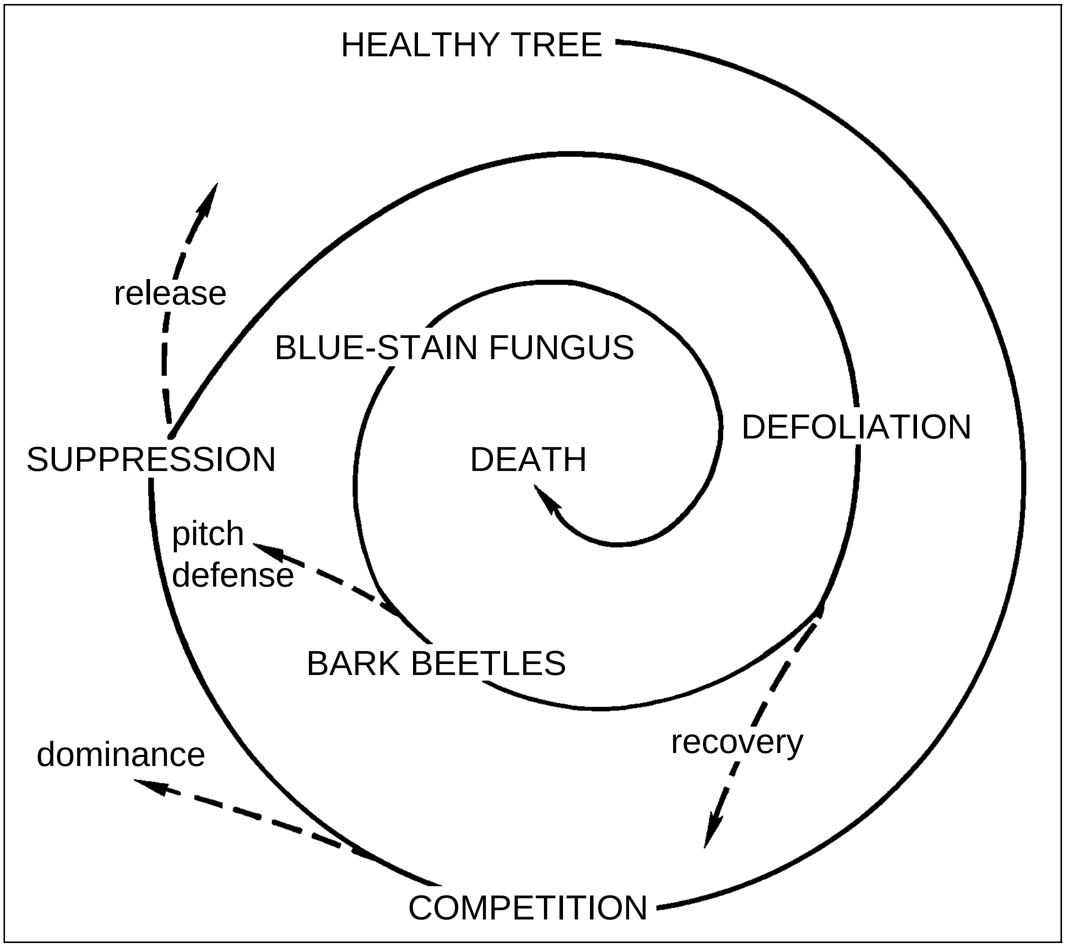
* Salvage harvest allowed only if an old-growth stand is killed by a catastrophic disturbance.

♦ Although appropriated NFFV funds cannot be used for planting because these lands are unsuitable, planting could occur if appropriated funds were provided by the benefiting resource (wildlife, fish, etc.) OR if a salvage harvest occurred and K–V funds were collected to finance the planting.

Planting. Planting is a powerful tool for influencing the future composition of a forest. In areas with substantial stand damage, planting can help reestablish a high proportion (60-70%) of early-seral, pest-resistant species. At lower elevations on warm dry sites, Douglas-fir or grand fir are the climax species and the choice of resistant species is limited, with ponderosa pine being the most obvious one. At higher elevations on cool moist sites, grand fir or subalpine fir are climax and the selection of non-host species is wider – lodgepole pine, western larch, ponderosa pine, western white pine, or quaking aspen could be used depending on the ecological conditions of the planting site.

If salvage treatments are completed in response to the stand damages described above, then the treated areas should be evaluated to determine their suitability for planting. Any reforestation evaluation should consider establishing western larch and ponderosa pine where they are the early-seral species; western white pine should also be considered for sites in the moist-forest potential vegetation group. If forest health is an objective, then planting should attempt to establish a future stand with at least two-thirds of the composition being early-seral species (Carlson and others 1983). This recommendation is particularly appropriate for areas with high risk of future spruce budworm or tussock moth defoliation.

Thinning. To be healthy, a tree needs a place in the sun and some soil to call its own (Powell 1999). When crowded by too many neighbors, a tree may not have enough soil and sun to maintain its vigor. A tree eventually dies if its vigor level drops so low that it can no longer heal injuries, resist insect and disease attacks, or otherwise sustain life (Veg Figure 13).



Veg Figure 13. Death spiral for a Douglas-fir tree in the Blue Mountains (adapted from Franklin and others 1987). In this example, a healthy tree is suppressed by larger trees. If not released from competition, the tree is predisposed to attack by defoliators. Once partially defoliated, the weakened tree is attractive to bark beetles such as Douglas-fir beetle (Wickman 1978), which carry blue-stain fungus. The fungus blocks water and sap movement in the tree and causes desiccation of the foliage. As a tree progresses along this spiral, the opportunities to use thinning or other silvicultural treatments to help it escape death become more limited.

An important silvicultural treatment is thinning, where some trees are removed so that those which remain receive additional sunlight, moisture and nutrients. The residual trees left by a thinning quickly increase their vigor, allowing them to produce more resin and defensive chemicals for warding off insect and disease attacks (Safranyik and others 1998).

Thinnings that anticipate density-related (competition-induced) mortality by removing trees from beneath the main canopy are called a low thinning or "thinning from below." Thinning from below can be advantageous because it creates an open, single-storied stand structure that is amenable to reintroduction of low-intensity surface fires. Low thinning also offers an opportunity to remove late-seral, pest-susceptible trees and thereby favor early-seral species (Powell 1994).

Over the long run, thinning and certain other silvicultural practices may be the most effective way to deal with defoliating insects such as western spruce budworm. Research from Montana found that thinning improved budworm resistance by increasing stand vigor, increasing budworm larval mortality during their dispersal period, and by reducing the budworm-host species in mixed-conifer forests. Thinning provided short-term protection for treated stands, and would presumably contribute to long-term resistance once landscape-sized areas were treated (Carlson and Wulf 1989, Carlson and others 1985, Powell 1999).

The plant association groups with apparent overstocking in Veg Table 27 should be field examined to determine if the high densities actually exist and, if so, then they should be evaluated to determine their suitability for a thinning treatment. Tables in Powell (1999) provide tree density recommendations by species and by plant association. They establish a "management zone" in which stand densities are presumed to be ecologically sustainable and relatively resistant to insect and disease problems.

Veg Figure 14 shows the location and distribution of upland-forest sites that would apparently qualify for the thinning treatment opportunity.

Improvement Cutting. Improvement cutting is defined as removal of less desirable trees in order to meet objectives related to species composition or vertical stand structure (Helms 1998). Trees of undesirable species or condition[8] are removed from the upper canopy, often in conjunction with an understory thinning. In the Phillips/Gordon analysis area, improvement cutting was considered as one silvicultural alternative for addressing the "reduction in early-seral species" issue. In that context, improvement cutting would be used in mixed-species stands that still have a viable component of early-seral trees (either ponderosa pine or western larch in this instance).

An improvement cutting scenario responds to several consequences associated with fire suppression and historical partial-cutting timber removals. After frequent surface fires were suppressed, and following removal of mature ponderosa pines and larches during partial-cutting entries, the ultimate result was multi-layered, mixed-species forest dominated by late-seral trees (Powell 1994, Sloan 1998). An improvement cutting would remove many (but not all) of the late-seral trees, thereby providing additional growing space for residual ponderosa pines and western larches and improving their vigor and longevity.

Veg Figure 14 shows the location and distribution of upland-forest sites that would apparently qualify for the improvement cutting treatment opportunity.

Forest Regeneration. Regeneration cutting is defined as removal of trees to assist regeneration already present (existing seedlings and saplings) or to make regeneration possible (Helms 1998). If regeneration is not already present before the trees are removed, it becomes established from seed trees left on site or by planting tree seedlings grown in a nursery.

In the Phillips/Gordon analysis area, regeneration cutting was considered as one silvicultural alternative for addressing the "reduction in early-seral species" and "inconsistent composition on dry-forest sites" issues. In that context, regeneration cutting would be used in situations where the desired species do not exist currently, or they exist in numbers too low to qualify as a viable seed source.

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[8] A determination of "desirable" or "undesirable" trees is based on the land management objectives of an area. Trees whose existing characteristics contribute to achieving the objectives of an area are desirable; undesirable trees lack such characteristics. This means that a change in objectives could result in a different determination of which trees are desirable or undesirable.

A regeneration cutting scenario was designed to respond primarily to ecologically inconsistent species composition on dry-forest sites. After frequent surface fires were suppressed over the last 90 years, late-seral, fire-sensitive species (Douglas-fir and grand fir) were able to get established on dry-forest sites that historically supported fire-tolerant species such as ponderosa pine (see "fire" discussion in the characterization section, page 13). If ponderosa pine is no longer present on these dry-forest areas, or is present in very low numbers only, then a regeneration treatment (shelterwood or seed-tree method) in conjunction with tree planting would be an effective way to reestablish it.

Veg Figure 14 shows the location and distribution of upland-forest sites that would apparently qualify for the forest regeneration treatment opportunity.

Understory Removal. This silvicultural practice is used in multi-storied stands, typically those with an overstory of early-seral trees and an understory of shade-tolerant species. The objective is to remove a high proportion of the understory trees and thereby improve overstory vigor by reducing inter-tree competition. When the overstory trees are mature ponderosa pines or western larches, this treatment is effective at ensuring their continued survival (Arno and others 1995).

Understory removals are implemented in at least two ways: on an area basis, or around individual trees. In the first method, understory trees are removed on areas having a relatively uniform stand composition and structure. Area-wide understory removals can be especially useful before initiating a prescribed fire program. In areas lacking uniform conditions, the understory is removed from around individual overstory trees with the objective of prolonging their survival by decreasing inter-tree competition and increasing tree vigor. *An understory removal would be particularly appropriate as a treatment to remove Douglas-firs and grand firs that have invaded on warm dry sites.*

Veg Figure 14 shows the location and distribution of upland-forest sites that would apparently qualify for the understory removal treatment opportunity.

Pruning. Pruning has traditionally been used to produce clear, knot-free wood for the lumber trade. But it can also play a role in achieving natural resource objectives. For example, the Phillips/Gordon watershed has experienced two intense outbreaks of spruce budworm over the last fifty years. In areas where budworm-host trees will continue to be a stand component, pruning could be used to remove the lower crown portion of host trees, thereby providing less food for survival and growth of budworm larvae.

After pruning trees that are large enough to have developed a fire-resistant bark, it would be possible to underburn mixed-species stands without "torching" the leave trees. Trees with short, pruned crowns would be less likely to serve as ladder fuels, thereby minimizing the risk of an underburn turning into a crown fire. Pruning must be carefully coordinated with the onset of an underburning program – if trees were pruned too soon, epicormic branching or "water" sprouts could occur on the stem and increase a tree's risk of torching in an underburn (Bryan and Lanner 1981, Oliver and Larson 1996).

Mechanical pruning would produce a stand that can be underburned much more quickly than waiting for natural pruning. For example, Veg Table 31 shows that ponderosa pine can self-prune quickly, but that dead branches often persist and that mechanical pruning would be advisable if a completely clean, branch-free bole is desired to minimize the risk of crown scorch or torching.

I recommend that pruning be considered as a future treatment for young stands on dry-forest sites. It may not be needed for at least 30 years, but it could then be coordinated with prescribed burning treatments as a way to lower the risk of pole-sized trees being killed by a fire (torching).

Veg Figure 14. Silvicultural treatment opportunities that could be used to respond to issues and concerns identified during the upland-forest analysis. Refer to the recommendations section of this report, pages 34-38, for detailed information about how the four silvicultural practices shown above could be implemented in the analysis area.

Veg Table 31. Natural pruning in ponderosa pine.

AGE	HEIGHT TO BASE OF THE LIVE CROWN (FEET)	BOLE LENGTH WITHOUT ANY DEAD BRANCHES (FEET)
20	3	1
30	18	2
40	28	3
50	36	4
60	45	7
70	50	11
80	56	19
90	61	27
100	65	29

Sources/Notes: From Kotok (1951). This data shows that ponderosa pine "lifts" its live crown very quickly (2^{nd} column) but dead branches are somewhat persistent, so that a "clean" branch-free bole requires a long time to develop (3^{rd} column). Note that these figures were derived from dense, wild stands; open, thinned stands would lift their crowns much more slowly than is shown above.

Prescribed Fire. After completing the understory removal, pruning or thinning treatments described in this section, managers should strongly consider using prescribed fire on dry-forest sites. Once ponderosa pines or western larches are 10 to 12 feet tall, a prescribed burn could be completed, although a low-intensity fire would leave most of the 6- to 8-foot trees undamaged as well (Wright 1978). From that point on, surface fires could be used on a regular cycle, usually at intervals of 10 to 20 years.

Fall burns are desirable from an ecological perspective because they replicate the natural fire regime and result in fewer losses of overmature pines to fire damage or to western pine beetle attack (Swezy and Agee 1991). One drawback of fall burning is that some species of root-feeding bark beetles are more common following fall burns. *Hylastes macer*, a root-feeding bark beetle that is a likely vector of black stain root disease in ponderosa pine, was most abundant following fall fires. Spider abundance was reduced temporarily following either spring or fall burning; spider diversity was significantly higher for fall fires as compared to spring burns (Niwa and others 2000).

Periodic burning can also be used to increase the nutrient capital of a site by rejuvenating snowbrush ceanothus, lupines, peavines, vetch, buffaloberry, and other nitrogen-fixing plants. Numerous studies have documented the slow decomposition rates associated with woody material in the interior West (Harvey and others 1994). This means that forests of the Interior Northwest may have depended more on nitrogen-fixing plants and low-intensity fires to recycle soil nutrients than on microbial decomposition of woody debris (Powell 2000).

Providing adequate levels of site nutrition is important for maintaining tree resistance to insects and diseases (Mandzak and Moore 1994). In central Oregon, for example, Reaves and others (1984, 1990) found that ash leachates (chemical substances produced when water percolates through the ash remaining after a fire) from prescribed burns in ponderosa pine forests had a direct negative effect on the growth of *Armillaria ostoyae*, cause of Armillaria root disease. Much of the Armillaria suppression was due to a fungus called *Trichoderma*, which was strongly antagonistic to *Armillaria ostoyae* in burned soils.

Fire may not be beneficial on all upland-forest sites; on moist areas, burns could favor dominance by bracken fern, western coneflower, and other allelopathic plants that inhibit conifer regeneration (Ferguson 1991, Ferguson and Boyd 1988).

On poor to moderate forest sites (generally dry areas with coarse or shallow soils and thin forest floors), broadcast burning can be detrimental from a nutritional standpoint. The short-term benefits of prescribed fire may be achieved at a cost of high soil pH, nitrogen and sulfur deficiencies, and other nutritional problems later in a forest's life (Brockley and others 1992). In central Oregon, prescribed fire was observed to cause a net decrease in nitrogen mineralization rates and a decline in long-term site productivity (Cochran and Hopkins 1991, Monleon and others 1997). Nutrient cycling is considered by some to be the most important ecosystem "service" provided by forest biomes (Costanza and others 1997).

I recommend that prescribed fire be used on dry-forest plant association groups (warm dry and hot dry) after multi-layer stands have received an understory removal or thinning treatment, and that it be considered as a future treatment for any plantations established on those same PAGs.

Prescribed fire will probably not be feasible for at least 30 years after plantations have been established, but it could then be used as a thinning tool to help create and maintain stand structures with low risk of crown fire or other undesirable fire behavior (Agee 1996, Morris and Mowat 1958, Scott 1998). Prescribed fire can also be used to protect young stands from wildfire; research showed that controlled burning afforded almost complete protection to trees from a subsequent wildfire (Wagle and Eakle 1979).

Enhancement of Limited Vegetation Components. By its very nature, ecosystem analysis at the watershed scale (EAWS) encourages analysts to adopt a broad perspective that emphasizes looking beyond site-level conditions to focus on ecological processes at the landscape scale. One potential pitfall of a broad perspective, however, is the risk of overlooking limited vegetation components such as quaking aspen, western white pine, or black cottonwood – many of which have a restricted distribution and are indistinguishable at a landscape scale.

For the Phillips and Gordon watersheds, native hardwoods (deciduous tree species) and western white pine are limited vegetation components of particular concern.

Quaking aspen is a good example of an ecosystem element that is valued for a wide variety of benefits. Its leaves and buds are a choice food for ruffed grouse, beaver, snowshoe hares, Rocky Mountain elk and many other species. And in winter, when foliage is no longer present, elk like to feed on its smooth white bark. After dying, aspen may be used by almost as many species as when alive – dead trees are prized by woodpeckers, flickers and many other species that use cavities (DeByle 1985). Although it may be difficult to prove (or quantify), it is very likely that aspen was historically more abundant in the Blue Mountains than it is now – fire suppression over the last 90 years has undoubtedly reduced its distribution.

Aspen is a clonal species that primarily regenerates by producing suckers from its root system (Schier and others 1985). Unfortunately, the suckers are highly palatable to elk, deer, and domestic livestock. In order to allow the suckers to persist and eventually grow above the browse height of large ungulates, it is a common practice to fence aspen clones to prevent grazing damage.

Aspen clones apparently do not exist in the Phillips/Gordon analysis area (based on the Walla Walla District hardwood GIS layer). If clones are eventually discovered, I recommend that they be fenced as quickly as possible.

Black cottonwood has a wide geographical distribution but it is mainly a tree of the Pacific Northwest. Like other cottonwoods, its habitat consists of wet areas – along live streams, around seeps, and on floodplains. It can tolerate yearly spring flooding and in some respects almost requires it for survival (Lanner 1984). Its growth is enhanced by frequent depositions of nutrient-rich sediments, and the fine gravels or sand supplied by periodic flooding provide an ideal substrate for cottonwood regeneration. After humans intervened in riverine ecosystems by curtailing spring flooding or by grazing domestic livestock, black cottonwood declined or disappeared altogether (Case and Kauffman 1997, Peterson and others 1996).

Unlike aspen, black cottonwood does not reproduce from root suckers, but it does sprout from the root collar and occasionally from rhizomes located close to the parent tree. It can also be propagated by sticking a branch cutting into moist soil and letting it form roots (Rose and others 1998). Although long-term trend data is unavailable for the Umatilla National Forest, black cottonwood is another species whose distribution is thought to be reduced from historical levels. Grazing by wildlife and livestock, and curtailment of frequent spring flooding, have combined with other factors to limit cottonwood regeneration.

I recommend that black cottonwood be planted on appropriate sites in both the upper portion of the dry forest PVG and in the moist forest PVG. Ecologically, black cottonwood is not considered an appropriate revegetation species for the cold forest PVG.

Western white pine, a mid-seral tree species, is sometimes found on cool moist, cool wet, and warm moist sites in the upper montane and lower subalpine vegetation zones (Powell 1998). It was characterized as having a restricted geographical distribution in the Blue Mountains (Haig and others 1941). In actuality, western white pine has a relatively wide distribution but it occurs as a minor species, seldom comprising a plurality of the basal area in any individual stand. Due to changes caused by fire suppression, bark-beetle outbreaks, white pine blister rust *(Cronartium ribicola)* and other factors, it is believed that white pine was more abundant historically in the northern Blue Mountains than at present.

Over the last 15 years, western white pine has increasingly been used in reforestation plantings because it survives well and contributes to biodiversity objectives. I recommend that rust-resistant sources of white pine continue to be planted on moist-forest sites where it is ecologically well adapted. In the near future, some of the historical plantations containing white pine will need to be thinned. Although stocking levels have not been developed specifically for white pine, I suggest that the Douglas-fir stocking levels also be used for white pine, as was recommended by Seidel and Cochran (1981) (Powell 1999).

Recommendations Synthesis. Veg Table 32 summarizes the area (acres), by subwatershed, for four of the silvicultural treatment opportunities discussed in this section (thinning, improvement cutting, regeneration, and understory removal). It was prepared to summarize the silvicultural practices that could be used in each subwatershed, while also providing a treatment comparison between subwatersheds.

A total of 23,401 acres in the Phillips/Gordon analysis area (71% of the forested lands) apparently qualify for one or more of the silvicultural treatment opportunities described in this section; 2,180 of those acres (9%) have a high treatment priority, 6,995 acres have a medium priority (30%), and 14,226 acres have a low priority (61%) (Veg Figure 15; see appendix 2).

Data Gaps and Analysis Limitations. One product of the recommendations step in ecosystem analysis at the watershed scale is identification of data gaps and analysis limitations (REO 1995). The following gaps and limitations were identified during analysis of upland forest vegetation for the Phillips/Gordon watershed:

1. *Future conditions were not considered*. Most of this vegetation analysis focused on reference (historical) and current conditions. There was no explicit consideration of future conditions. Unfortunately, the inter-agency Federal process developed for watershed analysis (REO 1995) does not require an assessment of future conditions. Perhaps future EAWS efforts would benefit from having the “third leg of the triangle” (i.e., future conditions) take its place alongside reference and current conditions. Analytical tools have recently been developed that would help evaluate future scenarios, such as the Vegetation Dynamics Development Tool (Beukema and Kurz 2000).
2. *A detailed landscape analysis was not completed*. Time and other constraints did not provide an opportunity to analyze landscape characteristics (patch, matrix and corridor metrics). It is believed that a landscape characterization could have improved our understanding of broad-scale ecosystem processes and their effect on vegetation patterns.

Veg Table 32. Area (acres) of treatment opportunities by subwatershed (SWS).

SWS	Thinning	Improvement Cut PP	Improvement Cut WL	Regeneration DF	Regeneration GF	Understory Removal
7A	2,133	545	363	326	240	1,038
7B	2,030	69	144	370	531	801
Total	4,163	614	507	696	771	1,839
84B	2,089	344	144	750	25	706
84C	1,206	671	—	248	153	949
84D	1,593	74	23	415	365	417
84E	936	379	23	1,242	562	1,640
84H	1,216	216	197	421	148	792
84I	3,673	655	353	1,095	342	2,105
Total	10,713	2,339	740	4,171	1,595	6,609
Grand Total	14,876	2,953	1,247	4,867	2,366	8,448

Sources/Notes: Derived from an analysis of treatment opportunities that would respond to issues and concerns identified during the upland-forest analyses. Acreages include NFS lands only. Thinning would respond to the "high forest density" issue. Improvement cut would respond to the "reduction in early-seral species" issue – PP shows the acreage of mixed forest that still contains a ponderosa pine component (CPmix cover type); WL shows the acreage of mixed forest that still contains a western larch component (CTmix cover type). Regeneration would respond to both the "reduction in early-seral species" and "inconsistent structure on dry-forest sites" issues – DF shows the acreage of Douglas-fir cover types (CD and CDmix) on dry-forest sites that could be regenerated to ponderosa pine; GF shows the acreage of grand fir cover types (CW and CWmix) on dry-forest sites that could be regenerated to ponderosa pine. Understory removal would respond to the "inconsistent structure on dry-forest sites" issue by converting multi-layer structures (stands with 2 or more layers) to a single-layer structure.

Note: acreages are not mutually exclusive between the four primary treatment opportunity categories; the same polygons (and their acres) may be included in more than one category.

3. *More recent field inventories may have improved analysis accuracy*. Inventory information is used to prepare assessments of watersheds, landscapes, entire National Forests, and other mid- or broad-scale land areas. Dating back to the early 1990s, inventory budgets have been steadily declining, quickly resulting in reduced availability of stand examinations and other high-resolution data sources. Although 48% of the analysis area was characterized using stand examinations (excluding walk-through surveys), 62% of the exams were acquired before 1993. No attempt was made to update the older exams using the Forest Vegetation Simulator model, so they may not accurately represent forest characteristics as they exist right now. I recommend that the Walla Walla District continue to acquire updated stand examinations whenever possible.
4. *Additional information about limited vegetation components would have been helpful*. Insufficient information was available about the distribution, condition, and trend of limited vegetation components such as quaking aspen, black cottonwood, and western white pine. The Walla Walla Ranger District compiles and maintains a GIS layer about hardwood (non-coniferous) plant species such as quaking aspen, black cottonwood, water birch, and curl-leaf mountain-mahogany. The hardwood layer was consulted but it provided no occurrence information (other than a 0.04-acre water birch stand) for the Phillips/Gordon analysis area, even though impressive stands of black cottonwood are known to exist in these drainages (excellent stands along Phillips Creek, for example).

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APPENDIX 1: DESCRIPTION OF FOREST DATABASES

Vegetation data for the Phillips/Gordon analysis area was stored in four databases. This document serves as a data dictionary for those databases, as described below:

- A published map contained in the back pocket of a 1902 report (Gannett 1902) was used for a coarse characterization of vegetation conditions as they existed in 1900 (Thompson and Johnson 1900). The database name is: **1900veg**.
- Colored, thematic, cover-type maps published by the Pacific Northwest Forest Experiment Station (Sankela and Lynch 1936) were used to characterize upland-forest conditions as they existed in the early 1930s. These maps were produced by county. The database name is: **1936veg**.
- Thematic, county-level forest type maps published by the Pacific Northwest Forest and Range Experiment Station (Moravets 1958) were used to characterize upland-forest conditions as they existed in the early to mid 1950s. The database name is: **1958veg**.
- Intensive stand examinations, walk-through examinations, and interpretation of aerial photography were used as data sources to characterize existing (current) vegetation for upland forests. This information was acquired between 1986 and 1999. Stand exam information was extracted from EVG and FSVeg databases; photo-interpretation data came from EVG. The database name is: **ExistPG**.

The remainder of this appendix describes each database field and its corresponding codes. Some fields were used only in certain databases, and those situations are noted in the field descriptions.

Polygon Number (**Poly** is the database field name): Polygons were numbered consecutively using the Arc GIS software.

Polygon Area (Acres): Total acreage within the polygon boundary; calculated using the Arc GIS software. Acreage figures include National Forest System lands only (except for private-land polygons).

Data Source (Sour): Provides the data source for each record. [Note: this field was not used with the historical databases since all of their data was derived from a single source, e.g., a published map.]

Code	**Description**
SE	Stand examination
PI	Photo interpretation exam
WT	Walk through field exam

Subwatershed (SWS): Provides the predominant subwatershed for each polygon. Derived by overlaying the subwatershed layer with the existing vegetation polygon layer, and then using Arc's "identity" function to determine the subwatershed that occupies the majority of each polygon.

Elevation (Elev): Mean elevation of the polygon, in feet; calculated by the Arc GIS software after gridding the polygon into 30-meter square pixels. Value is an average of the pixels within a polygon.

Slope Percent (SlpPct): Mean slope percent of the polygon; calculated by the Arc GIS software after gridding the polygon into 30-meter square pixels. Value is an average of the pixels within a polygon.

Aspect (Asp1; Asp2): Mean aspect of the polygon; calculated by the Arc GIS software after gridding the polygon into 30-meter square pixels. Value is an average of the azimuth calculations, in degrees, for the pixels within a polygon. The azimuth value (Asp1) was converted to a compass direction (Asp2) using this relationship:

Code	**Description**
LE	Level (sites with no aspect; slope percents <5%)
NO	North (azimuths >338° and ≤23°)

Code	Description
NE	Northeast (azimuths >23° and ≤68°)
EA	East (azimuths >68° and ≤113°)
SE	Southeast (azimuths >113° and ≤158°)
SO	South (azimuths >158° and ≤203°)
SW	Southwest (azimuths >203° and ≤248°)
WE	West (azimuths >248° and ≤293°)
NW	Northwest (azimuths >293° and ≤338°)

Plant Association (Ecoclass): The predominant plant association was recorded for each polygon in the ExistPG database. When a polygon was characterized using a stand examination, the plant association from the stand exam was used; for polygons characterized using other data sources, a potential vegetation map was used to assign a plant association (see Veg Table 2). Plant associations were recorded using a 6-digit Ecoclass code (see Hall 1998). There are too many Ecoclass codes to list here. See Powell (1998), table 2, or Hall (1998) for a list that relates each Ecoclass code to the vegetation type it represents.

Plant Association Group (PAG): This derived field was based on data in the *plant association* field. Refer to Powell (1998) for a description about how plant associations were assigned to PAGs.

Code	Description
Cold Dry UF	Cold Dry Upland Forest PAG
Cool Moist UF	Cool Moist Upland Forest PAG
Cool Very Moist UF	Cool Very Moist Upland Forest PAG
Cool Wet UF	Cool Wet Upland Forest PAG
Hot Dry UF	Hot Dry Upland Forest PAG
Warm Dry UF	Warm Dry Upland Forest PAG
Warm Moist UF	Warm Moist Upland Forest PAG
Warm Very Moist UF	Warm Very Moist Upland Forest PAG
Nonforest	Nonforest vegetation types (no Ecoclass, PAG, PVG info available)

Potential Vegetation Group (PVG): This derived field was based on data in the *plant association group* field. Refer to Powell (1998) for a description about how the PAGs were assigned to PVGs.

Code	Description
Cold UF	Cold Upland Forest PVG
Dry UF	Dry Upland Forest PVG
Moist UF	Moist Upland Forest PVG
Nonforest	Nonforest vegetation types (no Ecoclass, PAG, PVG info available)

Structural Class (Struc): Structural classes were derived using database queries. The queries used combinations of the overstory cover *(OvCov)*, overstory size *(OvSiz)*, understory cover *(UnCov)*, and understory size *(UnSiz)* fields. Queries differed slightly by PVG. Veg Tables 33 and 34 (at the end of this appendix) show the structural class queries. See O'Hara and others (1996) and Powell (2000) for additional information about structural classes.

Code	Description
OFMS	Old Forest Multi Strata structural class
OFSS	Old Forest Single Stratum structural class
SECC	Stem Exclusion Closed Canopy structural class
SEOC	Stem Exclusion Open Canopy structural class
SI	Stand Initiation structural class
UR	Understory Reinitiation structural class
YFMS	Young Forest Multi Strata structural class
NF	Nonforest (no structural class determined for nonforest polygons)

Cover Types (CovTyp): These codes describe the predominant tree species composition for each polygon. Polygons were considered nonforest when the total canopy cover of trees was less than 10 percent; cover types were not determined for nonforest polygons. Types where one species comprises more than half of the stocking are named for the majority species; types where no one species comprises more than half of the stocking are named for the plurality species along with a modifier ("mix") to denote the lack of a majority species (Eyre 1980). Cover type codes are described below.

Code	**Description**
Admin	Administrative sites
BU	Burned area (used in 1936 only)
CA	Subalpine fir is the majority species
CAmix	Mixed forest; subalpine fir is plurality species
CC	Clearcut (used in 1958 only)
CD	Douglas-fir is the majority species
CDmix	Mixed forest; Douglas-fir is plurality species
CE	Engelmann spruce is the majority species
CEmix	Mixed forest; Engelmann spruce is plurality species
CL	Lodgepole pine is the majority species
CLmix	Mixed forest; lodgepole pine is plurality species
CP	Ponderosa pine is the majority species
CPmix	Mixed forest; ponderosa pine is plurality species
CT	Western larch (tamarack) is the majority species
CTmix	Mixed forest; western larch is plurality species
CW	Grand fir is the majority species
CWmix	Mixed forest; grand fir is plurality species
NF	Nonforest ("Grass" and "Shrub" were only codes used for nonforest polygons)

Total Canopy Cover (TotCov): Total canopy cover was recorded for all vegetation polygons. Total canopy cover refers to the percentage of the ground surface obscured by plant foliage.

Cover Class (CovCls): This derived field was based on data in the *TotCov* field. It was used for the forest density analysis. Each forested polygon in the ExistPG database was assigned to one of five cover classes, as described below:

Code	**Description**
10-29	Live canopy (crown) cover is between 10 and 29 percent
30-45	Live canopy cover is between 30 and 45 percent
46-65	Live canopy cover is between 46 and 65 percent
66-80	Live canopy cover is between 66 and 80 percent
>80	Live canopy cover is greater than 80 percent

Stocking Class (Stocking): For the ExistPG database, this field was derived using data in the *TotCov* field. For 1936veg and 1958veg, a stocking value was provided by the map code.

Code	**Description**
L	Low stocking (10-40 percent)
M	Moderate stocking (41-70 percent)
H	High stocking (71-100 percent)

Canopy Layers (NLay): The number of canopy layers was recorded for all forested polygons in the ExistPG database, as described below:

Code	**Description**
1	1 layer present
2	2 layers present

Code	Description
3	Three or more layers present

Overstory Cover (OvCov): For polygons with a forest cover type code, the canopy cover associated with the overstory layer was recorded in this field. When added to the understory cover value, the total should equal the canopy cover of the polygon as a whole (as coded in the *TotCov* field).

Overstory Size Class (OvSiz): For polygons with a forest cover type code, the predominant size class for the overstory layer was recorded using these codes:

Code	Description
1	Seedlings; trees less than 1 inch DBH
2	Seedlings and saplings mixed
3	Saplings; trees 1–4.9” DBH
4	Saplings and poles mixed
5	Poles; trees 5–8.9” DBH
6	Poles and small trees mixed
6.5	Small trees 9–14.9” DBH
7	Small trees 9–20.9” DBH
7.5	Small trees 15–20.9” DBH
8	Small trees and medium trees mixed
9	Medium trees 21–31.9” DBH
10	Medium and large trees mixed
11	Large trees 32–47.9” DBH
12	Large and giant trees mixed

Overstory Species (OvSp1, OvSp2): For polygons with a forest cover type code, one or more of the following tree species codes were recorded. Species are not shown in order of predominance in ExistPG.

Code	Description
ABGR	Grand fir
ABLA2	Subalpine fir
ACGL	Rocky Mountain Maple (tree size)
ALNUS	Alder (species not determined; tree size)
ALSI	Sitka Alder
LAOC	Western Larch
PICO	Lodgepole Pine
PIEN	Engelmann Spruce
PIMO	Western White Pine
PIPO	Ponderosa Pine
POTR2	Black Cottonwood
PSME	Rocky Mountain Douglas-fir
SALIX	Willow (tree size)
TABR	Pacific Yew (tree size)

Understory Cover (UnCov): For polygons with a forest cover type code and two or more canopy layers, the canopy cover associated with the understory layer was recorded in this field. When added to the overstory cover value, the result should equal the total cover of a polygon (as coded in the *TotCov* field).

Understory Size Class (UnSiz): For polygons with a forest cover type code and two or more canopy layers, the predominant size class for the understory layer was recorded in this field. Codes were the same as those described above for the overstory layer.

Understory Species (UnSp1, UnSp2): For polygons with a forest cover type code and two or more canopy layers, one or two tree species were recorded for the understory layer. Note: species are <u>not</u> shown in decreasing order of predominance in ExistPG.

Map Code (MapCode): This field was used in the 1900veg, 1936veg, and 1958veg databases. It provides the map attribute associated with each polygon. These map codes can be thought of as a concatenated string of individual characteristics, e.g., type, stand size, stocking, age, and other features were combined as an attribute "string" that was used to label a polygon. Lookup tables were used to decipher the map code and thereby "extract" individual data items (type, size, etc.) from the attribute string.

Harvest (Harvest): For both the 1936veg and 1958veg databases, it was possible to identify whether some of the polygons had been previously affected by timber harvest, as shown below:

Code	**Description**
Y	Timber harvest had occurred

Age (Age): For the 1936veg database only, it was possible to assign an age classification to some of the polygons, as shown below:

Code	**Description**
EA	Even-aged stand
UA	Uneven-aged stand

Purity (Purity): For the 1958veg database only, it was possible to assign a purity rating to some of the forested polygons, as shown below:

Code	**Description**
M	Mixed-species composition
P	Pure (single-species) composition

Treatment Opportunity (Thin, ImpCut, Regen, UndRem, Prior): For the ExistPG database only, it was possible to identify tentative treatment opportunities for some of the forested polygons. Treatment opportunities are designed to respond to issues and concerns identified during the upland-forest analysis. Thinning, improvement cutting, forest regeneration, and understory removal were included in the database. A priority field (**Prior**) was also included to identify polygons with the highest treatment priority.

Veg Table 33. Forest structural classes as related to canopy strata and tree size.

	SIZE CLASS OF UPPERMOST STRATUM		
NUMBER OF CANOPY LAYERS OR STRATA	SEEDLINGS/SAPLINGS (< 5" DBH)	POLES AND SMALL TREES (5 TO 20.9" DBH)	MEDIUM TREES (> 21" DBH)
1	Stand Initiation	Stem Exclusion	Old Forest Single Stratum
2	Not Applicable	Understory Reinitiation	Old Forest Multi Strata
3	Not Applicable	Young Forest Multi Strata	Old Forest Multi Strata

Sources/Notes: Adapted from Stage and others (1995). This generalized classification scheme was used when deriving forest structural classes for the 1936veg and 1958veg databases.

Veg Table 34. Methodology used to derive forest structural classes for the ExistPG database.

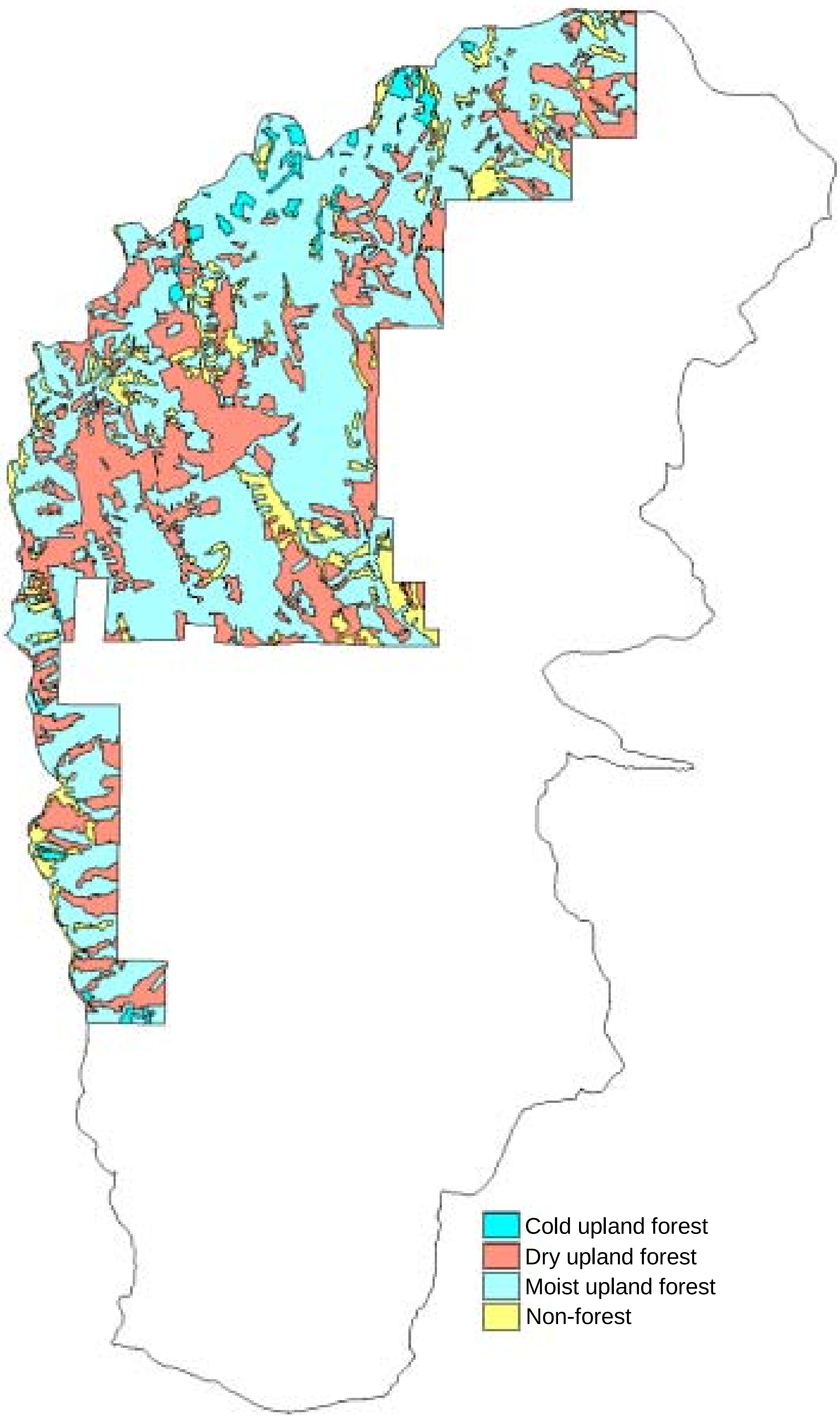
PVG	Order	OvSiz	OvCov	UnCov	UnSiz	Class	Remarks
COLD UPLAND FOREST	1	7.5-12	≥ 30	> 20		OFMS	Size class 7.5 included to account for LP and SF types
	2	7.5-12	≥ 30	≤ 20		OFSS	Size class 7.5 included to account for LP and SF types
	3	≥ 5	> 60	≥ 10		UR	
	4	≥ 5	>10, ≤ 60	≥ 10		YFMS	Differs from Hessburg; they used: OvCov ≥ 10%, ≤ 60
	5	≥ 5	> 70	< 10		SECC	
	6	≥ 5	>10, ≤ 70	< 10		SEOC	*Note*: > 10% OvCov was not used by Hessburg et al.
	7	< 5				SI	Overstory consists of seedlings and saplings
	8	≥ 5	≤ 10	<10		SI	Neither overstory nor understory has viable canopy cover
	9	[≥ 5]	[≤ 10]	≥ 10	< 5	SI	Nonviable overstory; understory is seedlings and saplings
	10	[≥ 5]	[≤ 10]	≥ 30	7.5-12	OFSS	Nonviable overstory; query based on understory data
	11	[≥ 5]	[≤ 10]	>70	≥ 5	SECC	Nonviable overstory; query based on understory data
	12	[≥ 5]	[≤ 10]	≤ 70	[≥ 5]	SEOC	Nonviable overstory; query based on understory data
MOIST UPLAND FOREST	1	8-12	≥ 30	> 20		OFMS	
	2	8-12	≥ 30	≤ 20		OFSS	
	3	≥ 5	> 60	≥ 10		UR	
	4	≥ 5	>10, ≤ 60	≥ 10		YFMS	Differs from Hessburg; they used: OvCov ≥ 10%, ≤ 60
	5	≥ 5	> 70	< 10		SECC	
	6	≥ 5	>10, ≤ 70	< 10		SEOC	*Note*: > 10% OvCov was not used by Hessburg et al.
	7	< 5				SI	Overstory consists of seedlings and saplings
	8	≥ 5	≤ 10	<10		SI	Neither overstory nor understory has viable canopy cover
	9	[≥ 5]	[≤ 10]	≥ 10	< 5	SI	Nonviable overstory; understory is seedlings and saplings
	10	[≥ 5]	[≤ 10]	≥ 30	8-12	OFSS	Nonviable overstory; query based on understory data
	11	[≥ 5]	[≤ 10]	>70	≥ 5	SECC	Nonviable overstory; query based on understory data
	12	[≥ 5]	[≤ 10]	≤ 70	[≥ 5]	SEOC	Nonviable overstory; query based on understory data

Veg Table 34. Methodology used to derive forest structural classes for the ExistPG database. [CONTINUED]

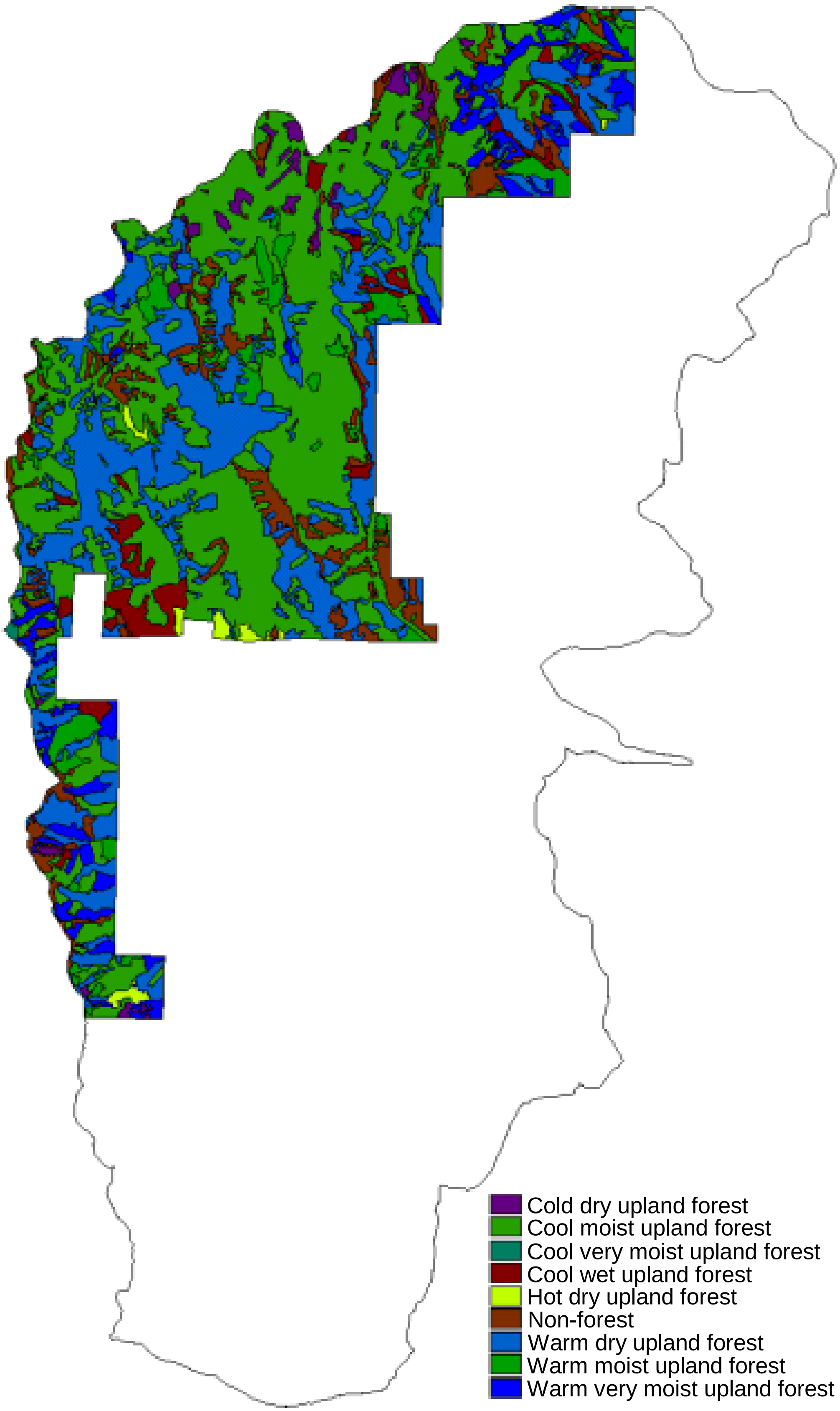
PVG	Order	OvSiz	OvCov	UnCov	UnSiz	Class	Remarks
DRY UPLAND FOREST	1	8-12	≥ 15	≥ 10		OFMS	*Note*: Except for SI, the Dry UF queries used ½ of the OvCov values used for the Cold and Moist UF queries
	2	8-12	≥ 15	< 10		OFSS	
	3	≥ 5	> 30	≥ 10		UR	
	4	≥ 5	>10, ≤ 30	≥ 10		YFMS	Differs from Hessburg; they used: OvCov ≥ 10%, ≤ 30
	5	≥ 5	> 35	< 10		SECC	
	6	≥ 5	>10, ≤ 35	< 10		SEOC	*Note*: > 10% OvCov was not used by Hessburg et al.
	7	< 5				SI	Overstory consists of seedlings and saplings
	8	≥ 5	≤ 10	<10		SI	Neither overstory nor understory has viable canopy cover
	9	[≥ 5]	[≤ 10]	≥ 10	< 5	SI	Nonviable overstory; understory is seedlings and saplings
	10	[≥ 5]	[≤ 10]	≥ 15	8-12	OFSS	Nonviable overstory; query based on understory data
	11	[≥ 5]	[≤ 10]	>35	≥ 5	SECC	Nonviable overstory; query based on understory data
	12	[≥ 5]	[≤ 10]	≤ 35	[≥ 5]	SEOC	Nonviable overstory; query based on understory data

Sources/Notes: Based on Hessburg and others (1999; page 47); deviations from their queries are noted in the remarks. Order is important for these calculations because if a polygon could meet more than one query option, a structural class should be assigned by the option with the lowest order number. Items in brackets are provided for information only; they are not necessary when using “blank, changeto” query statements.

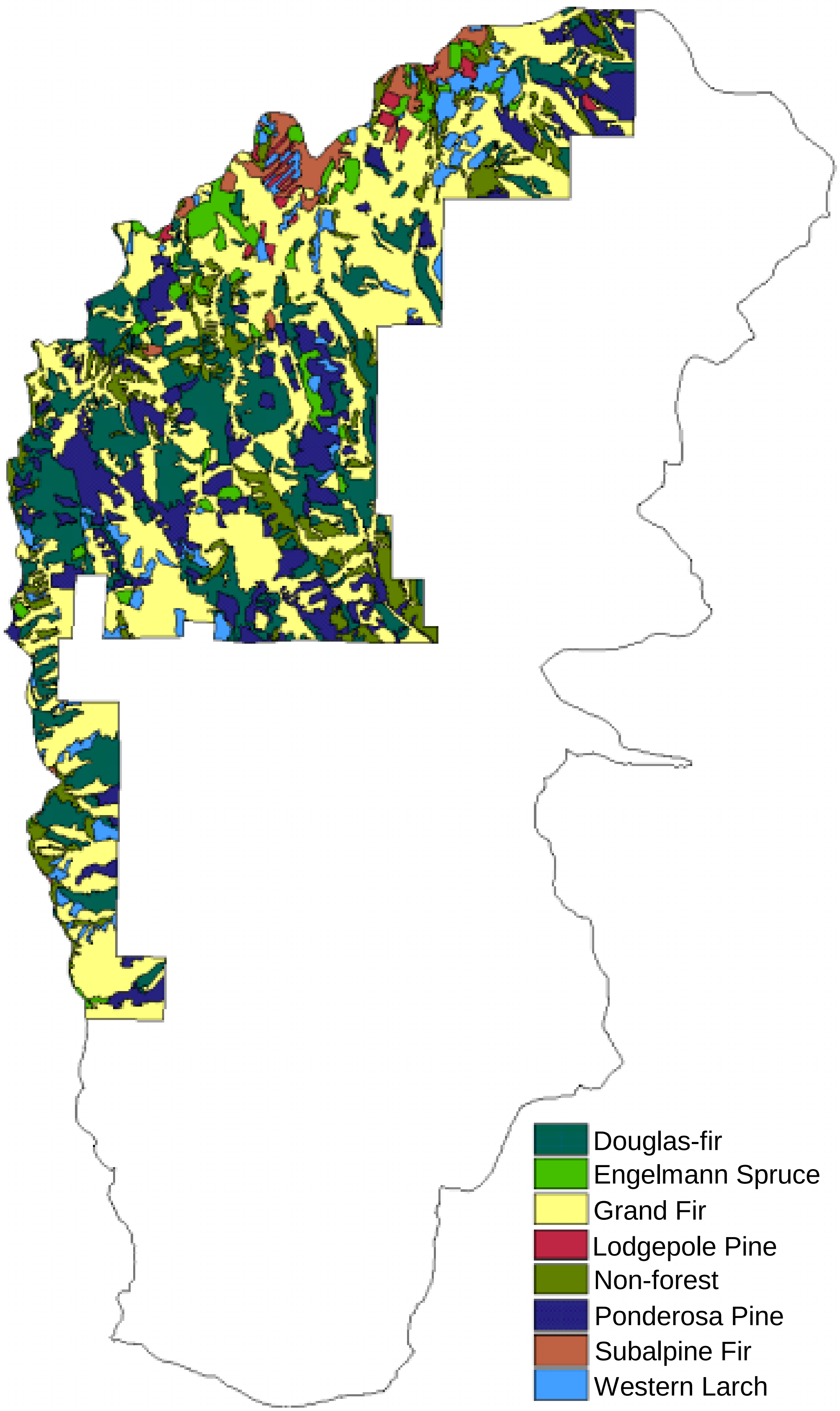
APPENDIX 2: COLOR MAPS



Veg Figure 1. Potential vegetation groups (PVGs) of the Phillips/Gordon analysis area. See Veg Table 4 (page 7) for additional information about the upland-forest plant association groups that were aggregated to form these potential vegetation groups.

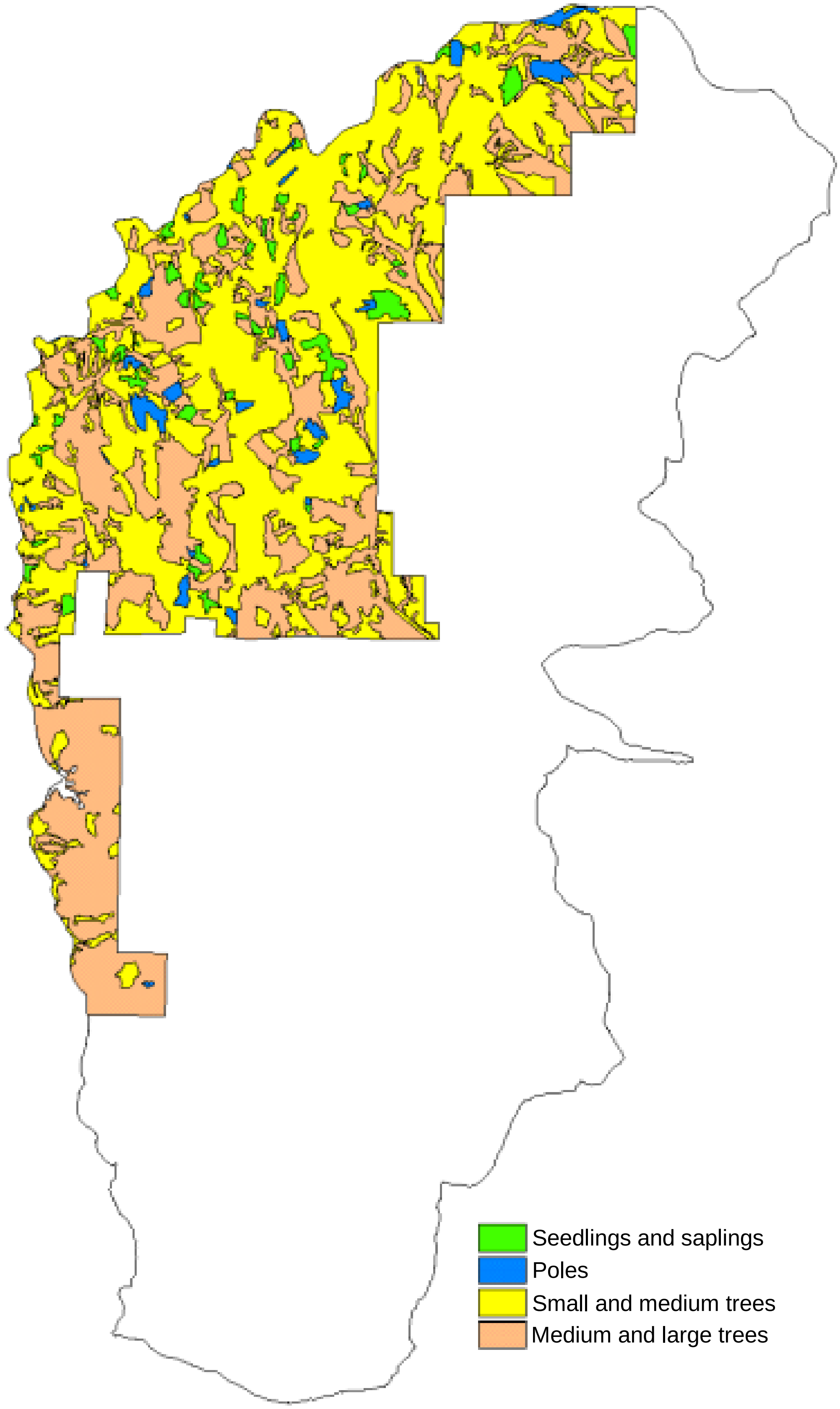


Veg Figure 2. Plant association groups (PAGs) of the Phillips/Gordon analysis area. Veg Table 4 (page 7) shows how plant associations were aggregated to form plant association groups.

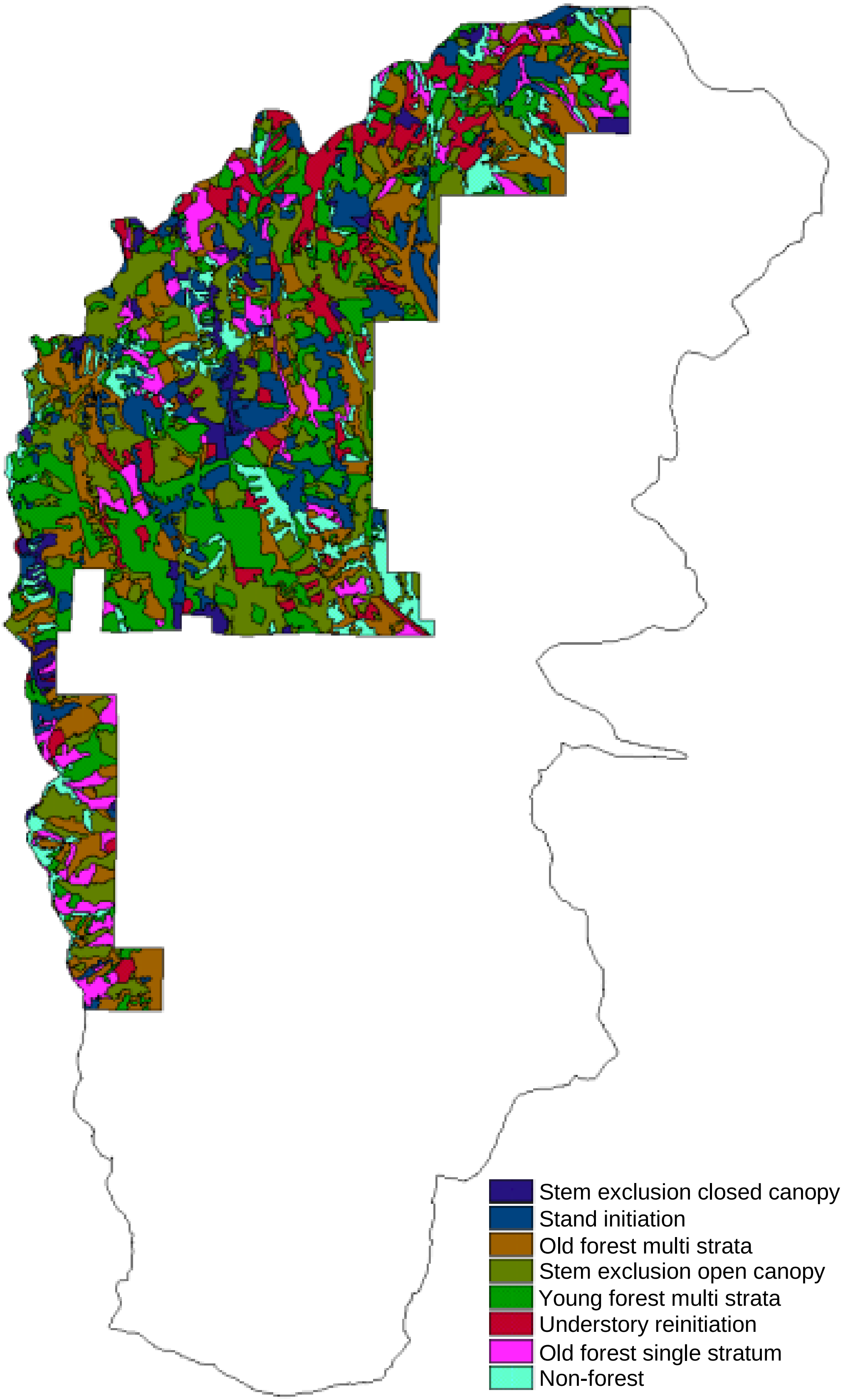


Veg Figure 6. Existing forest cover types of the Phillips/Gordon analysis area. Veg Table 10 (page 20) describes existing forest cover types in more detail.

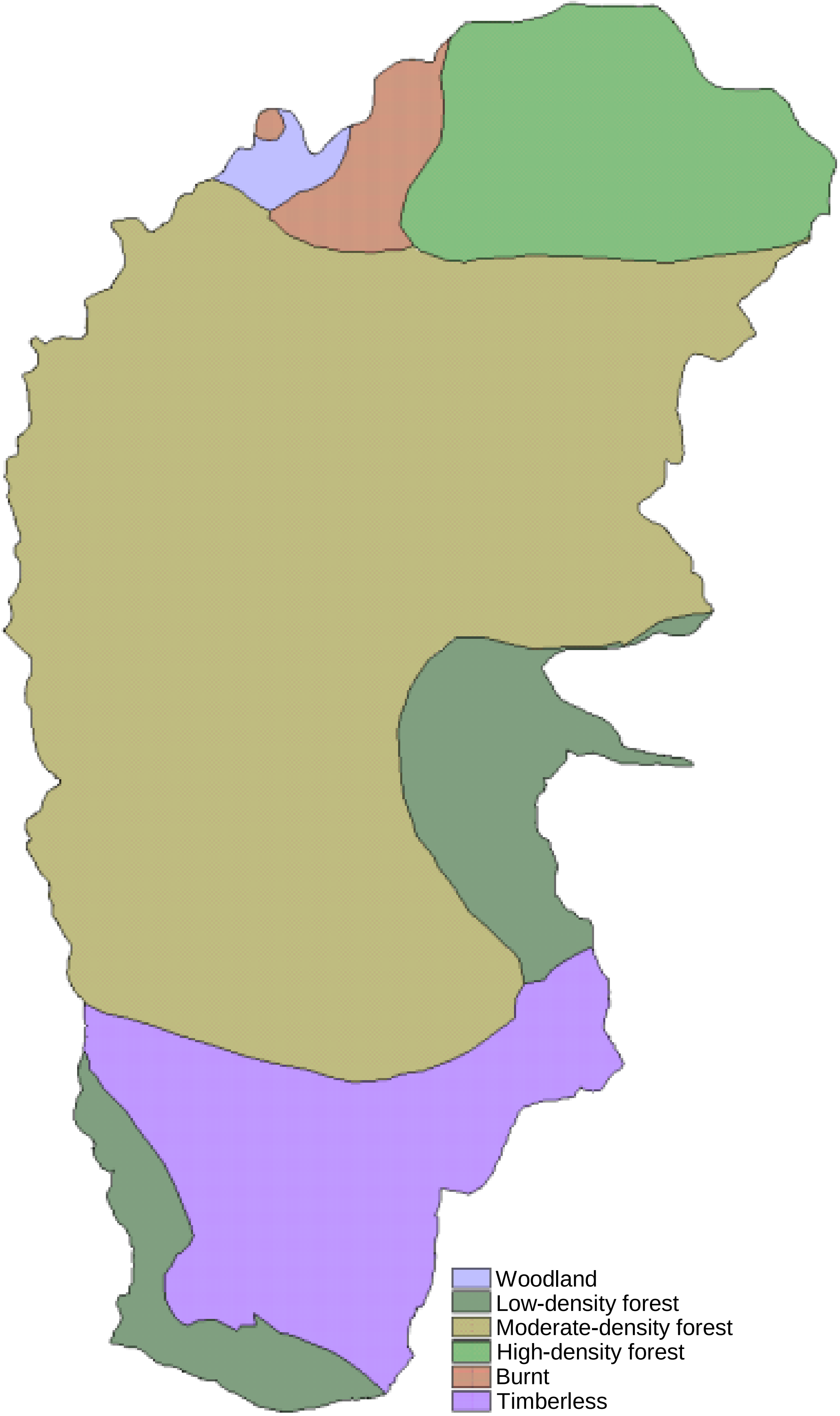
Veg Figure 7. Existing forest density classes of the Phillips/Gordon analysis area. Veg Table 12 (page 21) describes existing forest density classes in more detail.



Veg Figure 8. Existing forest size classes of the Phillips/Gordon analysis area. Veg Table 14 (page 22) describes existing forest size classes in more detail.

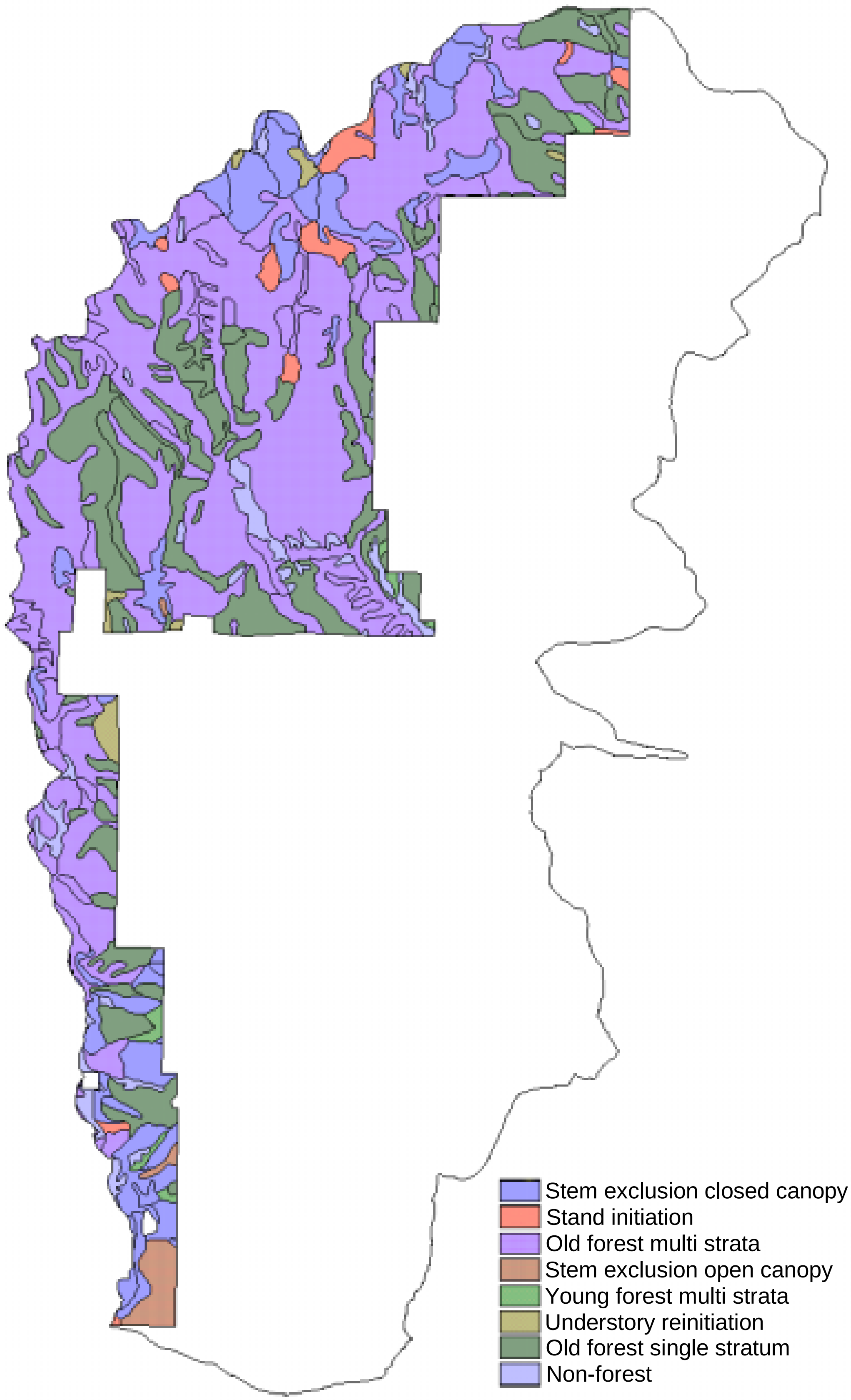


Veg Figure 9. Existing forest structural classes of the Phillips/Gordon analysis area. Veg Table 16 (page 23) describes existing structural classes in more detail.

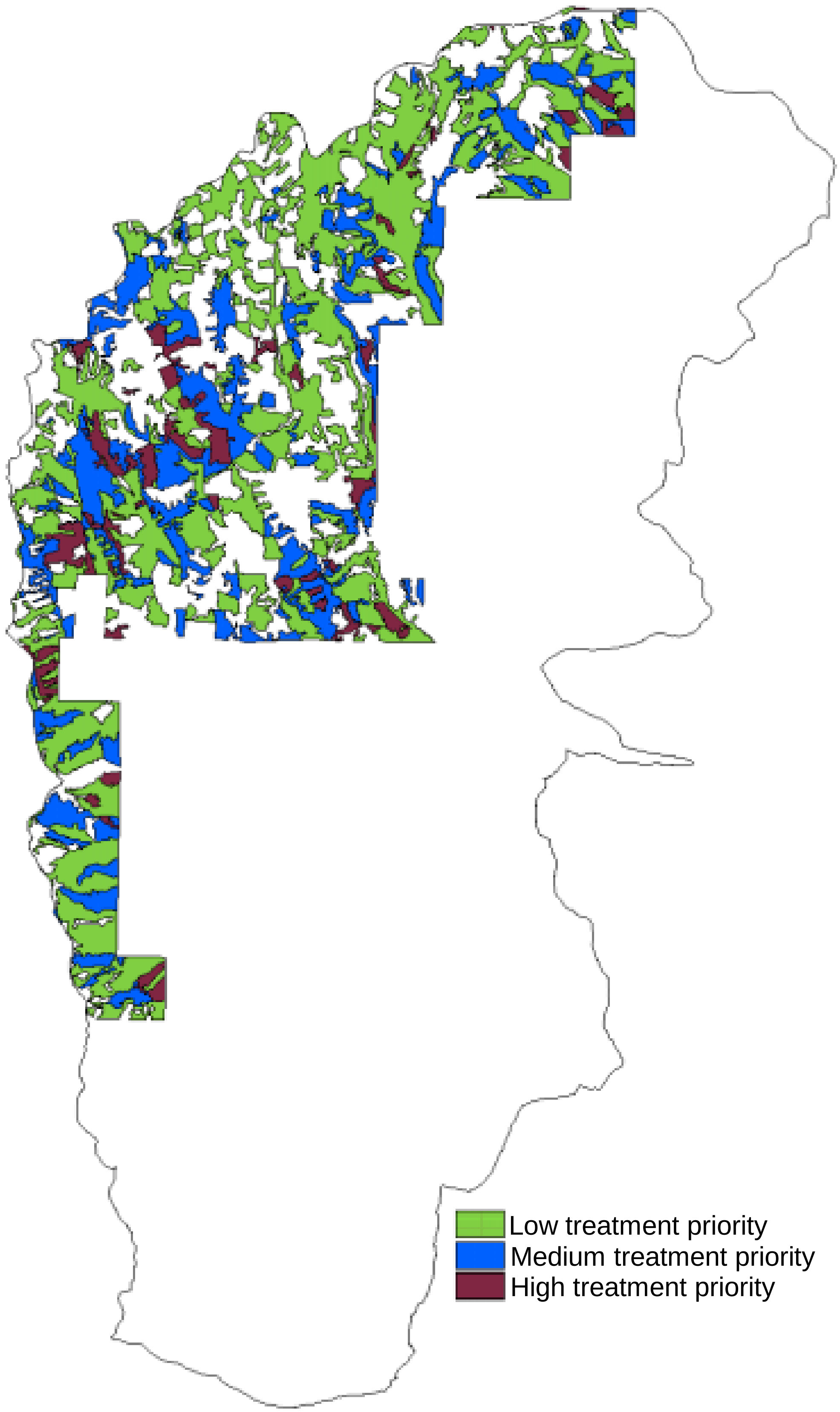


Veg Figure 10. Vegetation conditions in the Phillips/Gordon analysis area as of 1900. Veg Table 20 (page 25) describes the vegetation condition codes in more detail.

Veg Figure 11. Historical forest cover types of the Phillips/Gordon analysis area (1936). Veg Table 21 (page 26) describes historical forest cover types in more detail.



Veg Figure 12. Historical forest structural classes of the Phillips/Gordon analysis area (1936). Veg Table 24 (page 27) describes historical forest structural classes in more detail.



Veg Figure 15. Simplistic prioritization of the silvicultural treatment opportunities depicted in Veg Figure 14. Areas shown as high priority qualify for three of the four treatment opportunities; medium areas qualify for two of the opportunities; and low areas qualify for one treatment opportunity.