WHITE PAPER

USDA Forest Service Pacific Northwest Region Umatilla National Forest

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Using General Land Office Survey Notes to Characterize Historical Vegetation Conditions for Umatilla National Forest[1]

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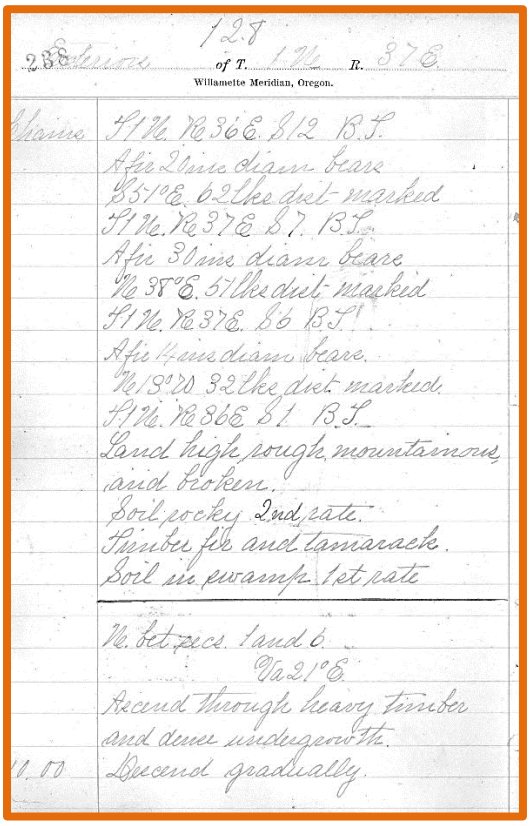

[1] White papers are internal reports; they receive only limited review. Viewpoints expressed in this paper are those of the author – they may not represent positions of USDA Forest Service.

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INTRODUCTION

An original public land survey system for the United States of America hearkens back to a land subdivision proposal first made by Thomas Jefferson in 1784. Much of his proposal was enacted into law, with minor changes, by a Federal Congress in 1796 (Wilson 1981).

Most of the western United States was subdivided into what we refer to as a rectangular grid system (townships, ranges, sections, etc.) by using methods evolved from this 18th-century legislation; settlement programs such as Homestead Acts could not convey public domain lands to settlers without consistent, repeatable, trustworthy, and well-documented land surveys.

Original public land surveys for Umatilla National Forest were completed primarily between 1879 and 1887. Notes and other records (such as planimetric maps) from these General Land Office (GLO) surveys provide the earliest systematically recorded information about vegetation composition for national forest system lands in the Blue Mountains of northeastern Oregon and southeastern Washington.

Survey notes contain comments about vegetation and other conditions (recently burned areas, Indian trails and wagon roads, rivers and streams, etc.) encountered along each survey (section) line. Tree species and size, along with distance and direction to a corner, were provided for up to four bearing trees at each section corner (fig. 1). If bearing trees were not available, surveyors selected a non-tree reference monument.

Notes from public land surveys (PLS) provide valuable information for an era predating widespread settlement by Euro-American emigrants. The fact that PLS predates settlement is no accident because land surveys were a prerequisite before public lands could be conveyed into private ownership via homestead acts.

The GLO references and literature cited section of this white paper provides literature describing General Land Office survey notes and their ecological uses.

Although GLO survey notes are used extensively in the Lake States region of this country, particularly for Michigan and Minnesota (see literature section), they receive relatively limited use for interior Pacific Northwest landscapes, where analysts are generally unfamiliar with their possibilities.

This white paper describes how GLO survey notes were interpreted and analyzed for Umatilla National Forest. It also describes how General Land Office survey notes collected between 1863 and 1934 were used to prepare maps (figures B-11 to B-13) displaying distribution of ecological systems (vegetation types), for Umatilla National Forest, as they are believed to have existed during a time period of 1879-1887.

GLO maps (figures B-11 to B-13) represent the earliest historical characterization of vegetation conditions for Umatilla NF.

Other historical information sources, including maps of various vintages, are described in white paper Silv-23, “Historical vegetation mapping” (Powell 2019). White paper Silv-23 illustrates Umatilla NF historical maps as image files (figures).

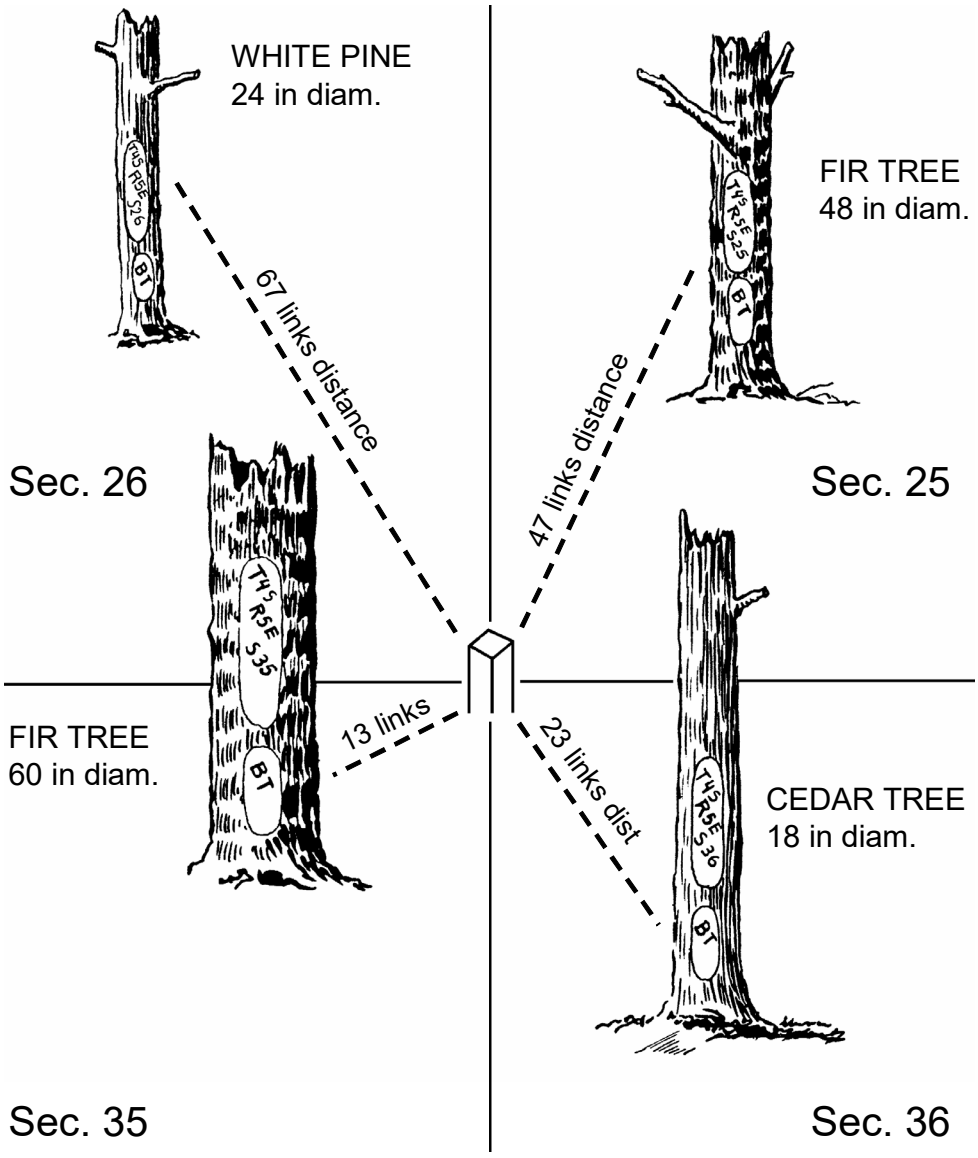


Figure 1–Schematic of a section corner, showing four bearing trees and their characteristics (species, diameter, and distance from corner, expressed in links). This diagram shows a section corner post (in the center and greatly enlarged to show its location) and four bearing trees, each of which is designated as such (BT) on a lowermost blaze on the stem (also see fig. 3). Upper blaze on each bearing tree provides pertinent public land survey information (township number, range number, section number) for the section in which it occurs. As shown in this diagram, each corner post is adjoined by four individual sections. Since section lines were surveyed using true north-south and east-west cardinal directions, each section forms a 90° quadrant at a corner post. This diagram shows all four quadrants occupied with a bearing tree; note that not all quadrants will have a bearing tree because a land surveyor was not required to designate one if an acceptable tree could not be located within 300 links (198 feet) of a corner post (also see fig. 3). Note: General Land Office surveys used a measurement system based on a 'chain.' A chain is 66 feet, and each chain consists of 100 links, so one link is .66 feet or approximately 7.9 inches. In the diagram shown above, distances between a corner post and each bearing tree are shown as links.

BACKGROUND

In January 1993, Don Wood, forest silviculturist for Ochoco National Forest, prepared a short review of a GLO survey-note project and presented it at a silviculture business meeting in Portland, Oregon (Wood 1993). Don described how information from GLO notes was used to estimate presettlement vegetation conditions, and how it served as a validation data source for their Viable Ecosystems Management process and guidebook (Simpson et al. 1994).

As a result of Don's presentation at a silviculture meeting, I recognized that GLO survey notes could potentially serve as a scientifically credible data source for characterizing presettlement vegetation conditions; for the interior Pacific Northwest, presettlement era is generally defined as mid to late 1800s (USDA Forest Service 1996).

Other data sources for characterizing presettlement conditions are scarce. Aerial photographs were not available until the late 1930s, and although diaries from Oregon Trail emigrants (Beckham 1991, Evans 1991) and early scientists such as Captain John C. Fremont, Henry Gannett, and Thornton T. Munger are useful sources (Gannett 1902, Jackson and Spence 1970, Munger 1917), they generally contain inherent biases (Forman and Russell 1983) and are seldom comprehensive in terms of geographical scope.

BRIEF DESCRIPTION OF PUBLIC LAND SURVEY

Public land survey followed a consistent and standardized process when it was used to subdivide lands in western United States. First, an initial starting point was selected. For Oregon and Washington, this starting point is located a short distance west of the city of Portland, Oregon.

A true north-south line was surveyed through the starting point, which became the principal meridian to which all other north-south subdivision lines are oriented. It is called the Willamette Meridian. At approximately six-mile intervals on both sides of Willamette Meridian, secondary north-south lines were surveyed parallel to the principal meridian.

Secondary north-south lines are called range lines. Six-mile wide areas between range lines are called ranges, and they are designated numerically both east and west of the principal meridian – Range 1 East, Range 1 West, Range 2 East, Range 2 West, and so forth.

A true east-west line was surveyed through the initial starting point, and this became the principal base line to which all other east-west lines are oriented. It is called the Willamette Base Line. At approximately six-mile intervals on both sides of the base line, secondary east-west lines were surveyed parallel to the base line.

Secondary east-west lines are called township lines. Six-mile wide areas between these lines are called townships, and they are designated numerically both north and south of the principal base line – Township 1 North, Township 1 South, Township 2 North, Township 2 South, and so forth.

This process of establishing township and range lines resulted in land and water areas being divided into grid cells measuring 6 × 6 miles (36 square miles per cell). Area within each individual six-mile-on-a-side cell is called a township.

A full township was subdivided into grid cells measuring 1 × 1 mile. Area within each individual one-mile-on-a-side cell is called a section.

Townships having fewer than 36 sections frequently occur, and this is due to error in early-day surveys, to presence of large bodies of water, to joining of adjacent surveys where different principal meridians or base lines were used, or for other reasons.

Due to surveying corrections made for convergence of meridian lines or to compensate for errors in surveying, some townships with a normal number of sections (36) cover more or less than 36 square miles of area, resulting in one or two outside tiers of sections being oversized or undersized.

In the Pacific Northwest region of the country, oversized or undersized sections are usually located in north or west tiers of sections (a tier is a strip of six sections).

When a township was surveyed by General Land Office, work was typically performed under contract. Surveys were completed by using two contracts – one for township exterior lines, and another for subdivisions establishing section lines within a township.

Township lines were surveyed first and then later subdivided into sections. Although there was typically little time separating the two surveys, it was not unusual for exterior and subdivision surveys to be completed in different years and by different surveyors.

Surveyors set a post at each section corner (at 1-mile intervals) and at each quarter-section corner (at ½-mile intervals). This means that a quarter-section corner (typically referred to as quarter corners) is located midway between each section corner (fig. 2).

As surveyors contracted by U.S. General Land Office subdivided and mapped the public domain in a rectangular grid, they recorded “the several kinds of timber and undergrowth, in the order in which they predominate” in hand-written field notes and on detailed maps (White 1991).

Information about kinds of timber and undergrowth plants has been extremely useful for describing presettlement vegetation conditions, which is one reason for why so many GLO land survey analyses have been completed for so many regions of the country – as illustrated by a References section later in this white paper.

Balance of this white paper describes how GLO land survey notes were interpreted for Umatilla National Forest, and how interpreted information was used to prepare a broad-scale map depicting presettlement vegetation conditions for an 1880s era.

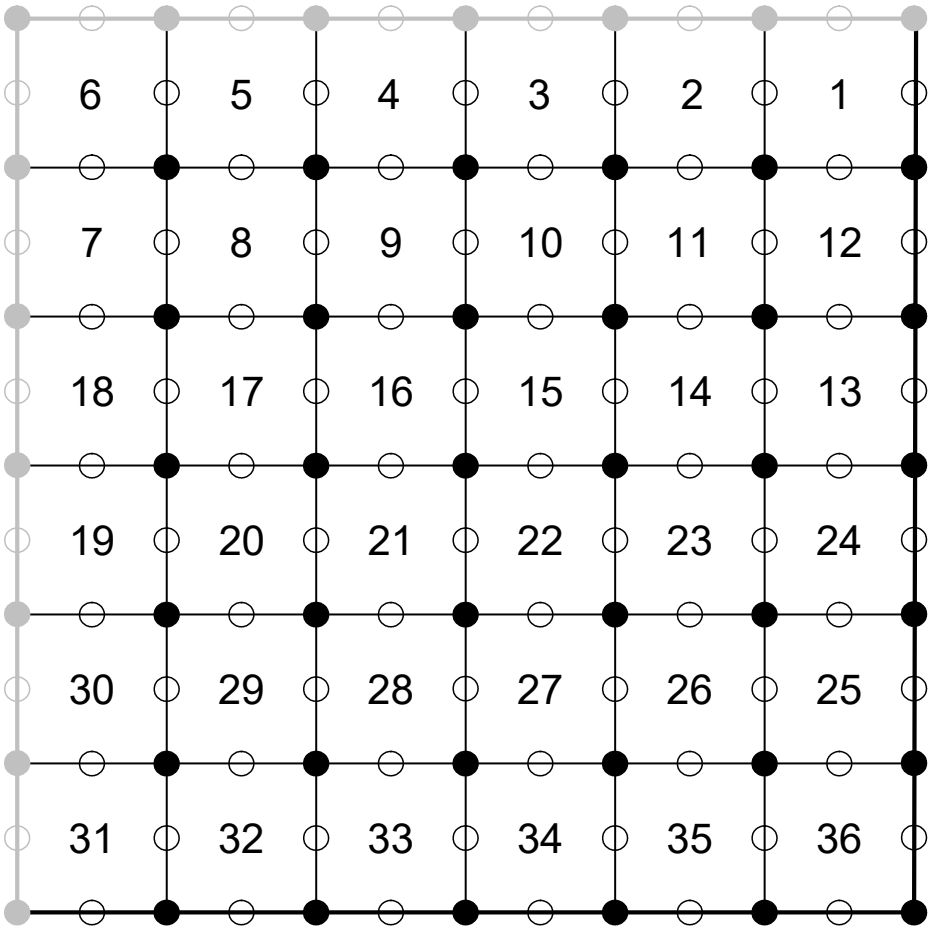


Figure 2–Schematic of a square 6- × 6-mile township, showing section corners (filled circles), quarter-corners located midway between each section corner (open circles), and a geometric pattern created by grid cells occurring on a 1 × 1 mile spacing. Each numbered grid cell is referred to as a section, and 36 sections in a standard township are designated by using a sinuous numbering scheme shown here. Note that west and north township lines are shown in a gray color to connote that exterior township lines are shared with adjacent townships; all four township lines are shown with thicker lines to separate them from interior section lines. [Exterior township lines were often surveyed by a different surveyor or contractor than interior 'subdivision' lines, and these two types of survey may have been completed at different times.] Township lines also function as section lines, so they have section corners and quarter corners established along them. Each section corner and quarter-corner spatial location was assigned a unique identification (ID) number in a GLO analysis theme created in the Umatilla National Forest's GIS system. ID number was stored in a GLO survey notes database for each data record corresponding to a corner or quarter-corner. Corners (filled circles) had up to 4 bearing trees recorded; quarter-corners (open circles) had up to 2 bearing trees. See a "Compiling a GLO Survey Notes Database" section later in this document for more information about ID numbers and how they were used when deriving a GLO-based map for Umatilla National Forest.

INTERPRETING GLO SURVEY NOTES

Critical to any interpretation of GLO data is an understanding of how surveyors selected bearing trees (Bourdo 1956, Grimm 1984, Nelson 1997).[2]

Because a primary purpose of bearing trees was to simplify relocation of posts, proximity to corners and quarter-corners was an important consideration for bearing tree selection. However, words such as “adjacent” and “nearly” in surveying instructions should not be construed as implying that selected bearing trees were always the closest individuals to a corner or quarter-corner.

Other criteria for bearing tree selection included tree size, vigor, and conspicuousness in an area. A blaze made upon bearing trees had to be of sufficient size to inscribe section, township, and range numbers (fig. 1) and, as such, GLO surveyors generally preferred medium size trees often ranging between 10 and 14 inches (Nelson 1997).

GLO survey instructions often included phrases such as this: “You will select for bearing trees those which are the soundest and most thrifty in appearance, and of the size and kinds of trees experience teaches will be the most permanent and lasting” (Habeck 1994, Nelson 1997). Due to the importance of this requirement, a guide was produced dealing exclusively with durability of bearing trees (White, Date unknown).

Some investigators noted occasional surveyor bias in selection of bearing trees. When White (1976) was working with GLO data for western Montana, he detected surveyor bias against both small-diameter and large-diameter trees, and this bias is understandable given tree selection criteria: small trees were not viewed as meeting the permanency standard (perhaps they were too ephemeral to survive fire and other disturbances) and large trees did not fit the longevity standard (because large trees were perceived to be old and expected to die soon).

Many different land surveyors were involved in establishing General Land Office surveys across Umatilla National Forest. These surveyors are listed in table 1.

At this point, not enough analysis of Umatilla NF GLO survey notes has occurred to indicate whether any surveyor-based bias might exist in the data.

Table 1: Frequency of GLO surveys by surveyor name.

GLO Surveyors	Frequency	Percent
unknown surveyor	2	1%
A.H. Simmons	2	1%
Aaron F. York	8	3%
Alfred A. Morrill	2	1%
Alonzo Gesner	5	2%

[2] Some GLO sources refer to trees identified at a section corner as witness trees, trees falling on a section line as line trees, and trees identified at quarter-corners (midway between section corners) as bearing trees. To avoid confusion, this document generally refers to all these trees as bearing trees.

GLO Surveyors	Frequency	Percent
Banford Robb & Hermon Gradon	4	1%
Charles L. Campbell	6	2%
Daniel P. Thompson & Daniel Chaplin	1	0%
David P. Thompson	1	0%
Dudley S.B. & John D. Henry	2	1%
E.A. Thatcher	1	0%
Edson D. Briggs	2	1%
Edward B. Dobbs	1	0%
Edward W. Sanderson	18	6%
Edwin S. Clark	4	1%
Eugene P. McCormack	4	1%
Everett A. Thatcher	2	1%
Francis Loehr	5	2%
Frank W. Campbell	35	11%
George R. Campbell	1	0%
George S. Pershin	28	9%
George Williams	2	1%
Henry Meldrum	10	3%
Herman D. Gradon	32	10%
Jacob C. Cooper	8	3%
James E. Noland	1	0%
James P. Currin	2	1%
James P. Currin & James E. Noland	9	3%
John A. Hurlburt	1	0%
John G. Collins & Clyde N. Carey	4	1%
John W. Kimbrell	5	2%
Lew A. Wilson	2	1%
Loehr & Knowlton	2	1%
Manius Buchanan	3	1%
Mark A. Fullerton	1	0%
Otis O. Gould	13	4%
Robert A. Farmer	2	1%
Robert F. Omeg	3	1%
Roy T. Campbell	21	7%
Rufus S. Moore	29	9%
Sewall Fruax? Fruix?	5	2%
Timothy W. Davenport	2	1%
W.B. Barr	3	1%
Walter D. Long	5	2%
William E. and George R. Campbell	4	1%
William E. Campbell	2	1%
William H. Odell	5	2%
William M. Bushey	2	1%
William R. Gradon	2	1%
William T. Evans	2	1%

GLO Surveyors	Frequency	Percent
Z.F. Moody	3	1%
Total	319	100%

Sources/Notes: Accounting for year of survey was based on an original worksheet for a township (which lists surveyor's name, year of survey, and township and range covered by the survey). Each instance of either an exterior or subdivision survey was tallied. For example, if Simmons completed both surveys for a township (exterior and subdivisions), then they were tallied as 2 surveys even if both were done under the same contract.

BEARING TREES

A surveyor was required to establish on-the-ground references for each section corner and quarter-corner. In forested lands, nearby trees were selected and blazed as bearing trees to identify corners. They are called bearing trees because a surveyor was required to take a compass bearing between the corner post and the center of a bearing tree. Bearing trees were used to help recover a corner after its post was lost, decayed, or destroyed (fig. 3).

When sufficient trees were available, section corners were referenced by four bearing trees and quarter corners by two bearing trees. According to a survey manual used as a standard reference after 1855, a surveyor was required to establish bearing trees by using these rules:

- For all section corners, four bearing trees were required to be established, one in each quadrant adjacent to a corner post;
- For all quarter corners, two bearing trees were required to be established, one in each section on either side of a quarter-corner;
- Bearing trees needed to be within 300 links[3] (198 feet or 60 m) of a corner (Habeck 1994), and there was no requirement to establish a bearing tree if none was available within that distance; and
- A bearing tree was supposed to have a minimum diameter of 2½ inches.

This information was required for each bearing tree:

- Species (local common name);
- Diameter, ostensibly as a diameter at breast height, but GLO data analyses indicate that diameter might have been estimated near a tree's base (see White 1976 and Habeck 1994); tree diameter was probably just a visual estimate rather than an actual measurement;
- Compass bearing from a corner post; and
- Distance from corner to center of a tree (no documentation if this was slope or horizontal distance, but it is assumed to be uncorrected slope distance).

[3] A link is one-hundredth of a chain and since a chain is 66 feet, then one link is .66 feet (i.e., there are 100 links per chain).

Figure 3–Quaking aspen tree designated as a bearing tree. A General Land Office surveyor was required to designate one tree in each of four 90° quadrants around a section corner as bearing trees (unless no trees were available within 3 chains, in which case a quadrant would not have a bearing tree). Selection of bearing trees was directed by contract requirements relating to tree size and tree durability; it was unusual to select an aspen unless no other suitable species were available because aspen was not viewed as a "durable" tree species (White date unknown).

In addition to bearing-tree information, surveyors recorded common names and diameters of line trees used to mark a section line between section corners (but no distances from the line were recorded for these trees).

At each section corner, a surveyor noted type of terrain, soil, undergrowth vegetation, timber, agricultural potential, and any unusual features. Surveyors also recorded major vegetation changes along section lines (such as when entering and leaving wetlands or crossing rivers, recently burned areas, and clearings).

As section lines were traversed, surveyors made note of a line entering or leaving forest cover with phrases such as "heavily timbered," "heavy open timber," or "scattering timber." GLO analyses indicate that when surveyors used words such as heavy, they

may have had a different connotation than what we would give them today. In GLO usage, heavy may have apparently been used to note presence of large-sized trees rather than a dense or heavy-stocking condition (Habeck 1994).

After 1850, survey instructions explicitly required that incidences of certain disturbance processes such as windthrow and fire be recorded in survey notes, along with certain natural phenomena such as river and stream widths.

This requirement allows GLO survey notes to be used, with some confidence, for analyzing a wide variety of ecosystem characteristics (Bourdo 1956, Schulte and Mladenoff 2001):

- Presettlement river widths (Beckham 1995a, b);
- Presettlement fire location and size (Batek et al. 1999, Grimm 1984, Maclean and Cleland 2003, Zhang et al. 1999);
- Presettlement windthrow patterns (Canham and Loucks 1984, Schulte and Mladenoff 2005);
- Presettlement vegetation composition and structure (Abrams and McCay 1996; Abrams and Ruffner 1995; Bragg 2002; Brown 1998; Comer et al. 1995; Cornett 1994; Galatowitsch 1990; Gordon 1969; Habeck 1961, 1962, 1964; Leitner et al. 1991; Nelson 1997; Radeloff et al. 1998, 1999; Schulte et al. 2002; Stearns 1949; Teensma et al. 1991; White 1976; White and Mladenoff 1994).

COMPILING A GLO SURVEY NOTES DATABASE

In November 1995, Martha King and I met with Gean Davidson, a volunteer who was interpreting GLO survey notes for the Deschutes and Ochoco National Forests. Gean provided examples of their database structure, along with GLO-derived maps produced for a Metolius watershed analysis, Deschutes National Forest.

After meeting with Gean Davidson and reviewing her GLO examples for Ochoco and Deschutes national forests, we decided to interpret GLO survey notes for Umatilla National Forest, starting with a Umatilla-Meacham watershed analysis.

After discussing analysis objectives and potential uses of GLO data, we decided to record more information from the notes than had been done for Ochoco and Deschutes national forests. We believed that additional information would make GLO data more useful for a wider variety of resource specialists.

Funding was obtained from traditional sources, and after Gean Davidson and the Umatilla National Forest's land surveyor (Dennis Gaylord) provided training, Martha King began interpreting GLO survey notes during winter of 1995-1996.

First step was to determine which quadrangle maps occurred within a Umatilla-Meacham watershed analysis area; full-sized paper copies were made for these quads. We then consulted with a geographical information system (GIS) specialist (Mike Hines) to discuss objectives and potential uses for GLO data.

After considering examples from other national forests, Mike created a GIS theme assigning unique ID numbers for each section corner, and for a midpoint of each section

line (these mid-points represent quarter-corners), occurring within the Umatilla National Forest's administrative boundary (fig. 2 describes corners and quarter-corners).

ID numbers provide a link between database records and geographical coordinates of their corresponding nodes (section corners) or line segments (section lines).

Next task was to acquire hard copies of GLO survey notes. Dennis Gaylord, land surveyor for Umatilla National Forest (now retired), maintained these notes on microfiche. Dennis explained procedures that GLO land surveyors were supposed to follow; he described how GLO microfiche files were organized; and he served as a technical advisor throughout the GLO notes project (at least until his retirement).

Paper copies of microfiche files for all townships within the Umatilla National Forest boundary were then made by using the Supervisor Office's microfiche reader and copier. At this point, Martha began interpreting and summarizing GLO survey notes and entering information into a non-normalized Paradox database (single-record or flat-file format). This initial interpretation was for a Umatilla/ Meacham watershed analysis area.

After finishing the Umatilla/Meacham watershed, GLO work progressed to the next analysis area: Desolation watershed. After that was the Tower Fire analysis area, followed by Middle Grande Ronde subbasin. After compiling a Middle Grande Ronde database, we decided to quit interpreting for individual analysis areas, and to begin a systematic process for interpreting GLO notes for the entire Umatilla National Forest.

Umatilla National Forest has approximately 1.4 million acres included on 95 primary base series quadrangle maps (1:24,000 scale). A GIS theme (developed by Mike Hines and described above) was used to print paper map sheets, for all 95 quad-map areas, showing ID numbers for corner nodes and section lines.

An accordion-style, legal-size folder was prepared for each of 120 townships occurring on Umatilla National Forest. These folders contain printed copies of GLO survey notes, and the folders are stored in a legal-size, 5-drawer file cabinet located at a FS warehouse on Byers Avenue in Pendleton, Oregon.

Processing (printing) microfiche copies of survey notes, and plotting out GIS maps, required between one and two months. Producing paper copies of notes (from microfiche) required several toner cartridges and many reams of paper.

Reading and interpreting GLO survey notes was the most time consuming part of this process, requiring over 100, 8-hour workdays for approximately 120 townships. Notes for some townships were relatively easy to process and took, on average, a day to finish; others took longer. Some notes were typed up while others were handwritten. It was found that paper printouts from microfiche records could be hard to read.

Since some surveyors included more information in their notes than others, it took more time to process townships with longer notes. A few townships were surveyed in a different pattern and order than they were supposed to be, and these notes took longer to process.

For some townships, only a quarter or a half of them contained national forest system (NFS) lands and, in some instances, GLO information was interpreted for NFS portions only. Generally, however, an entire township was entered into the database even if it contained a relatively small portion of NFS lands.

Based on our experience, a reasonable time estimate for the transcription portion of this process is to allow one full workday per full township.

Finally, quality control: printing out a hard copy of the GLO database and checking it for inconsistencies and errors, while carefully checking that a legal description was correctly matched to its corresponding ID number (from the GIS theme), required several days for a large analysis area such as the Umatilla National Forest.

It is important that an interpreter understand the basic GLO survey process, and how GLO survey notes are filed and organized. For example, it is common to have multiple surveys available for the same area, with some surveys taking place after 1930.

We also found that it is not necessary to copy everything on the fiche files; microfiche notes should be reviewed before printing them.

DERIVING GLO VEGETATION MAPS

The previous section described how GLO survey notes for Umatilla National Forest were located, copied, and then interpreted to create a GLO survey notes database. Appendix A provides a short description for each field in the GLO database.

Because each record in a GLO survey notes database corresponds to a unique spatial location (an ID number assigned to each section corner and quarter-corner), a GLO dataset is easily imported into GIS as a point coverage. These data points can then be plotted to provide a quick visual portrayal of species distribution patterns (and this is often how GLO data was being used on Deschutes and Ochoco national forests in mid to late 1990s).

A point coverage, however, is often inappropriate for describing distribution of a continuously varying landscape feature such as vegetation, so more relevant data forms (such as grid (raster) or polygon coverages) are generally viewed as desirable. To derive either of the non-point data forms, some form of spatial interpolation is required, often involving sophisticated and complex analytical techniques such as kriging or cokriging (Chang 2002).[4]

After compiling a GLO survey notes database and checking it for errors, GLO data was provided to a contractor (Titan Corporation) for additional analysis, including spatial interpolation. Titan Corporation then subcontracted with Oregon Natural Heritage Infor-

[4] Kriging, a spatial interpolation technique, assumes that spatial variation of an attribute is neither totally random nor deterministic. Cokriging uses one or more secondary variables, which are correlated with a primary variable of interest, during an interpolation process. Landform position and other variables derived from a digital elevation model, for example, can be used during cokriging to help limit distribution of riparian vegetation types to valley bottom landforms (Chang 2002).

mation Center (ONHIC), an organization affiliated with The Nature Conservancy, because they had previous experience analyzing GLO data by using a spatial interpolation methodology (see appendix B).

ONHIC performed a wide array of sophisticated and complicated spatial analyses such as cokriging and maximum entropy modeling to produce a map depicting historical vegetation conditions for Umatilla National Forest. Map units consist of ecological systems, a classification framework developed by a non-profit organization called NatureServe (Comer et al. 2003).

“Ecological systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding” (Comer et al. 2003). A Umatilla National Forest GLO vegetation map (fig. B-11) includes 15 different ecological systems, and they are described in Appendix C.

[Note that appendix C also describes unmapped ecological systems that are believed to exist on Umatilla NF, but they occur at a spatial resolution too fine to delineate by using GLO survey notes.]

An Umatilla NF GLO map is available in two forms: as a GIS theme in grid (raster) format, usable with ArcMap software, and as a color PDF file that can be printed like a small poster (17" × 22" format; see figure B-11 in appendix B).

Which time period does an Umatilla NF GLO map pertain to? For a color PDF version of a GLO map, a time period of 1879 to 1887 is shown in the annotations because approximately 62% of original GLO surveys occurred during this 9-year period (table 2).

Appendix B is based on metadata materials supplied by ONHIC, and it describes how they prepared the Umatilla NF’s GLO map. Titan Corporation also produced a poster (34" × 44" format) providing a summary of the map preparation process described in appendix B; the poster is available from the Umatilla NF’s History website, along with other GLO materials.

As described in appendix B, tree species occurring at section corners or quarter-corners were analyzed individually (by species) during cokriging and maximum entropy phases of the map preparation process. This process generated maps for 18 individual tree and shrub species; these species maps are available from the GLO section of the Forest’s history website (but only as color PDF files in 8½" × 11" format; no GIS format is available for individual tree-species mapping).

Table 2: Frequency of GLO surveys by year of survey.

Year of Survey	Frequency	Percent
1863	2	1%
1864	2	1%
1866	5	2%
1871	4	2%
1872	3	1%
1873	5	2%
1874	1	0%
1876	2	0%
1877	6	2%
1878	2	1%
1879	21	6%
1880	13	5%
1881	46	16%
1882	47	15%
1883	16	6%
1884	35	10%
1885	3	1%
1887	10	3%
1889	4	1%
1891	2	0%
1895	3	1%
1897	1	0%
1898	2	0%
1899	8	3%
1900	2	0%
1901	5	1%
1903	2	0%
1904	3	1%
1905	2	0%
1907	2	1%
1910	2	0%
1915	4	1%
1931	9	2%
1932	6	2%
1933	4	1%
1934	2	0%
1935	2	0%
1881-82	1	0%
1882-83	3	1%
1884-85	2	1%
1901-02	2	0%
1902-03	3	1%
1909-10	1	0%

Year of Survey	Fre-quency	Per-cent
1920-21	2	0%
1931-32	2	0%
1931-33	5	1%
1932-1935	4	1%
1932-33	4	1%
1933-34	2	0%
Total	319	100%

Sources/Notes: Year of survey was based on a worksheet for a township (listing surveyor's name, survey year, and township/range covered by survey). Each instance of an exterior or subdivision survey was tallied. If a township had both surveys in the same year, it would be tallied as 2 even if completed under the same contract. Surveys started in one year but not finished until the next year are listed separately.

APPENDIX A: DESCRIPTION OF DATABASE FIELDS

Survey Year: This field contains the year a survey was completed, not the year a contract was signed. This completion date is recorded on the contract page, listed as “date survey started” and “date survey completed.”

The date a survey was signed (by the head surveyor) is sometimes the same as one of these, but not always.

Some surveys were started in one year but not finished until the following year due to weather, fire, or other reasons. When this occurred, both years were recorded in the master list.

The master database contains the recorded survey year for each subdivision of a township.

Quad: This field contains the number of a primary base series quadrangle map.

TRSD: This refers to Township, Range, Section, and Description for a survey. For example, 01N3506E means it is Township 01N, Range 35 East, Section 06, and East node (midpoint of east line of Section 01). Survey notes for T01N, R35E, Section 06, and North Line boundary would be referenced as 01N3506NL.

Nontree Ref: A non-tree reference point was used when there weren’t any trees at all, or when trees were not close enough (within 300 links) to use as bearing trees, either at a section corner or at the mid-point of a line survey.

Spec# / Diam# / Dist#: These fields provide tree species, diameter of a tree, and tree distance from a corner or mid-point of the line for bearing trees.

Section corners could have up to four trees, and midlines could have up to two trees (one tree in each section adjoining the line).

Line#Spec and Line#Diam: These fields provide tree species and tree diameter for any tree found along the section line or exterior boundary line during a survey.

Creek# and Creek# Size and Creek# Course: A river, stream, creek, branch, or ditch found along a survey line would be named, if known, and referenced with a description, including size of the feature and direction it was flowing.

Beckham (1995a, 1995b) provides good examples of how GLO survey notes were used to characterize historical river conditions for Grande Ronde and Tucannon rivers.

Cult Imp#: Any other feature (cultural improvement) noted along a survey line by a surveyor is listed here. We included only four columns in the database to keep it from getting too large. If there were more cultural items, they were listed in a comment field.

Cultural improvements include railroads, Indian trails, wagon roads, stock trails, homesteads, burns, and others.

Timber Density and Timb Spec#: At the end of a paragraph for each section, surveyors typically provided an accounting of any timber species seen along the survey route. Surveyors often make note of overall density of timber traversed (such as dense, heavy, or scattered).

Soil Type A-B: At the end of each section paragraph, a surveyor makes note of soil types, referencing them as #1-4. It is assumed that these numerical ratings are quality levels – type 1 soils are better than type 4 soils. And, it is assumed that when making soil ratings, surveyors were primarily considering agricultural potential. Soil descriptions might also include a descriptive term such as rocky or loamy.

Undergrow#: At the end of a section paragraph, a surveyor lists different species of shrubs noted along a survey line. Some surveyors were more descriptive than others, and referenced up to 24 different types of plants observed.

Node and Line: Node is a unique GIS-created number identifying each section corner and a mid-point for each section line. A node is a point coordinate referencing a section corner, or mid-point of a section line usually located at 40 chains.

The line identifier is also a unique GIS-based number used to identify each section line across the Umatilla National Forest.

Each node and line ID number is linked to a TRSD identifier in the database. There is a GIS map showing node and line ID numbers for each section in an analysis area.

Note that all node/line GIS maps are currently hanging in a map case at the Supervisor's Office (the map case is stored at a FS warehouse on Byers Avenue in Pendleton).

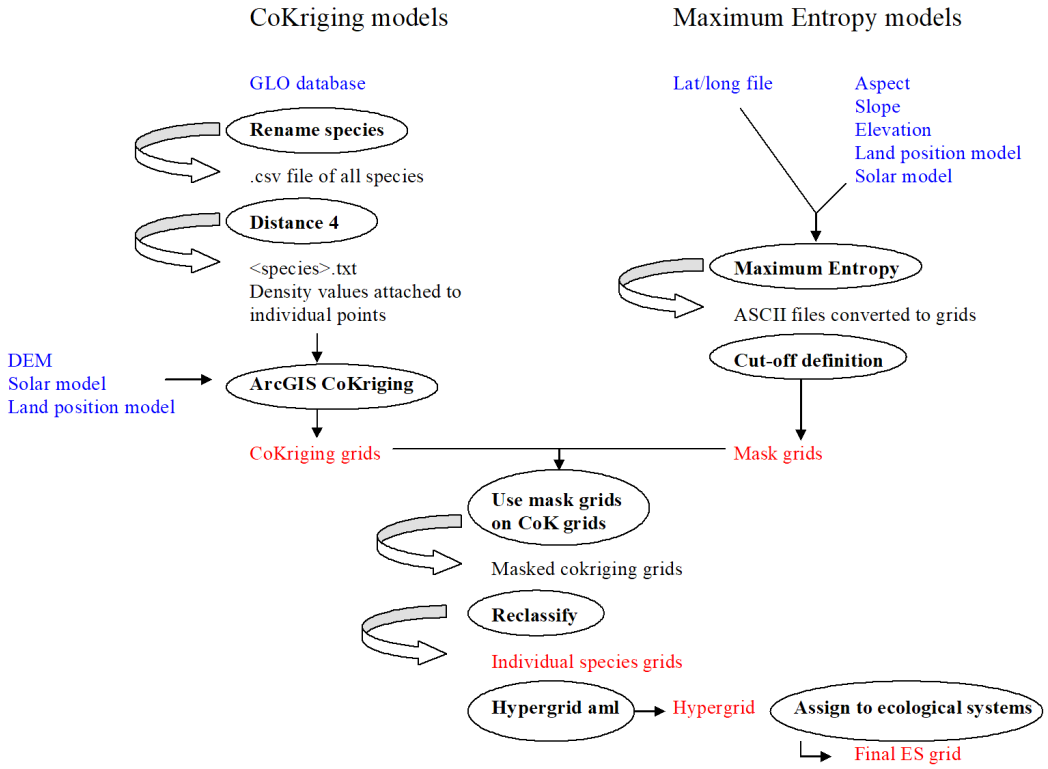
Comments: This field was used to list additional information not included in another field: additional tree species found along survey lines, additional cultural improvements (and 'cultural improvements' included natural phenomena such as fire scars/burns), other water features, and further shrubs or undergrowth species.

At the end of each survey, there is usually a General Description paragraph providing summary information from a surveyor. This general description was reviewed for interesting information that could be included in a comments field.

APPENDIX B: GLO UMATILLA MODELS[5]

Summary

Using tree data from an Umatilla NF GLO survey, two types of grids were generated on a species-by-species basis: a CoKriging model based on density values, and a Maximum Entropy model used as a mask to limit distribution of CoKriging grids. Final species grids were combined into a 'hypergrid,' and unique combinations of tree species were reclassified into ecological systems. The following diagram summarizes an analysis process in a flow-chart format (red text shows intermediate steps):



1. Data preparation

A frequency was run for CornerTrees table of a GLO database to list different species; this list was cross-walked to current tree names by vegetation specialists (Jimmy Kagan and John Christy), as follows (species count in parentheses):

ALDER: Mountain alder (63)
ALPINE FIR: Subalpine fir (4)
B--RBERY: Bearberry (1)
BALM: Black cottonwood (11)
BALSAM FIR: Grand fir (4)
BIRCH: Birch (7)

[5] This information, dated February 2005, was provided by Oregon Natural Heritage Information Center as metadata to Titan Corporation, Geospatial Services Division, during completion of task order 1 for contract 53-84N8-0-001 between USDA Forest Service and Titan Corporation.

BLACK PINE: Lodgepole pine (454)
BULL PINE: Lodgepole pine (3)
CHERRY: Cherry (5)
COTTONWOOD: Black cottonwood (11)
DEAD FIR: Douglas-fir (1)
DEAD PINE: Ponderosa pine (1)
DOUBLE FIR: Douglas fir (10)
DOUBLE PINE: Ponderosa pine (1)
DOUBLE SPRUCE: Engelmann spruce (1)
DOUBLE WHITE PINE: Western white pine (1)
FIR: Douglas fir (7352)
HEMLOCK: Mountain hemlock (16)
JUNIPER: Western juniper (85)
LARCH: Western larch (3)
LODGEPOLE PINE: Lodgepole pine (65)
MAHOGANY: Mountain mahogany (15)
MESQUITE: Mesquite (3)
PINE: Ponderosa pine (7965)
POPLAR: Black cottonwood (1)
QUAKING ASH: Quaking aspen (2)
QUAKING ASPEN: Quaking aspen (8)
RED FIR: Douglas fir (283)
ROCKY MTN MAPLE: Rocky Mountain maple (10)
SILVER FIR: Grand fir (1)
SPRUCE: Englemann spruce (851)
SPRUCE PINE: Lodgepole pine (12)
WESTERN LARCH: Western larch (2044)
WHITE FIR: Grand fir : (130)
WHITE PINE: Western white pine (8)
WILLOW: Willow (23)
YELLOW FIR: Grand fir (3)
YELLOW PINE: Ponderosa pine (707)
YEW: Yew (10)

After renaming, 21 species remained, for a total of 20,175 trees at 8232 corner points:[6]

Bearberry (1) (not modeled – not enough points)
Birch (7)
Black cottonwood (23)
Cherry (5)
Douglas-fir (7646)
Engelmann spruce (852)
Grand fir (138)

[6] After accounting for fact that bearberry, mesquite, and western white pine were not modeled for various reasons, this means that 18 tree or shrub species were used for modeling. GLO web-site includes separate maps showing modeled distribution for these 18 species individually.

Lodgepole pine (534)
Mesquite (3) (not modeled – not enough points)
Mountain alder (63)
Mountain hemlock (16)
Mountain mahogany (15)
Ponderosa pine (8674)
Quaking aspen (10) (no CoKriging model – only Maximum Entropy)
Rocky Mountain maple (10)
Subalpine fir (4)
Western juniper (85)
Western larch (2047)
Western white pine (9) (not included in a hypergrid – all density values smaller than 1)
Willow (23)
Yew (10)

2. Distance 4 analysis

A GLO CornerTrees table (with the new names) was imported into a computer program called Distance 4 (http://www.ruwpa.st-and.ac.uk/distance/) (Figure B-1). Distance sampling and analysis is explained in a book by Buckland et al. (2001).

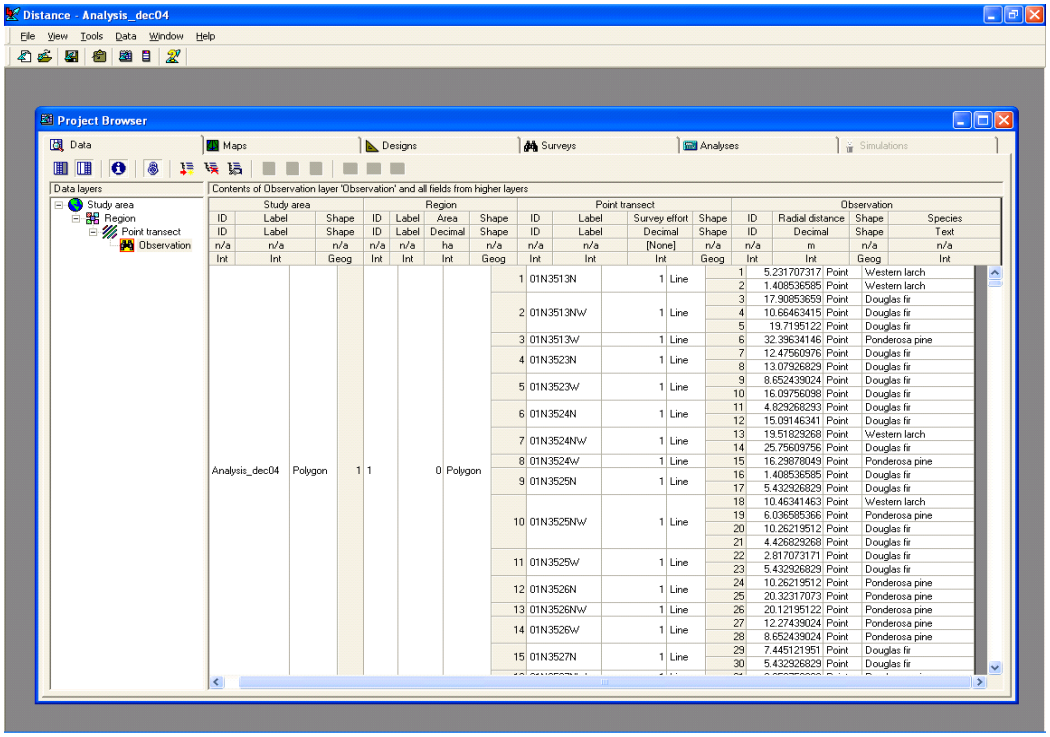


Figure B-1–Example showing Distance 4 input data.

Analysis was run species by species, except for bearberry and mesquite, by using Distance 4 conventional distance sampling with half-normal key function and a cosine series expansion (program's default settings). Output stats were saved to a text file (one per species), and density values were attached to corner tree points (Figure B-2).

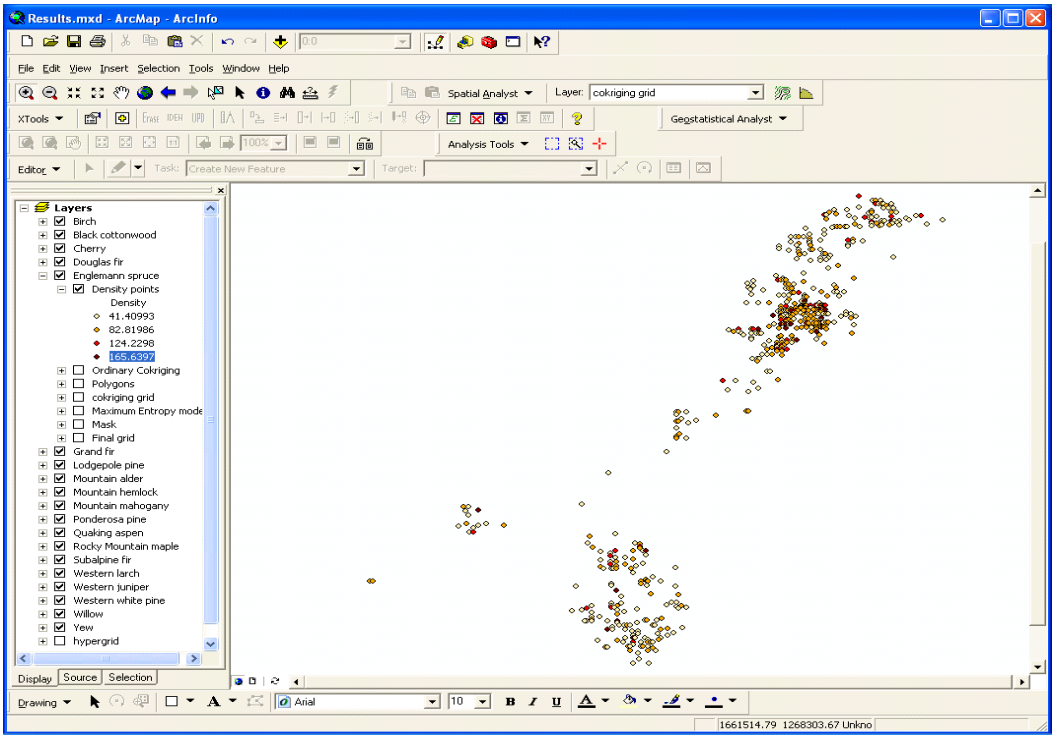


Figure B-2–Example showing distribution of density values for Engelmann spruce.

For an unknown reason, Distance 4 refused to output a model for quaking aspen (programmers of Distance 4 were contacted but could not fix this problem). Instead of a CoKriging model, eight corner tree points where aspen were located were buffered by 9000' (approximately the size of cokriging value patches around single points) and assigned a density class of 1.

3. CoKriging

We used the CoKriging option of Geostatistical Analyst in ArcGIS 8.3.

Models used three co-variables: elevation (extracted directly from a 10-meter DEM; figure B-3), a landform model (figure B-4), and a solar model (figure B-5). A 10-m digital elevation model was generated by piecing together data from Oregon (http://buccaneer.geo.orst.edu/dem/data/dem10oregon.html) and Washington (http://www.or.blm.gov/gis/resources/dataset.asp?cid=102).

Landform model was derived from the DEM and describes a landscape as one of 13 base components of cliffs → coved → wet flat areas. Inclusion of a solar index model is based upon work by NatureServe, and ORNHIC, in which 'south-westerness' of a cell is derived from the amount of potential illumination a cell receives on the two solstice and equinox dates.

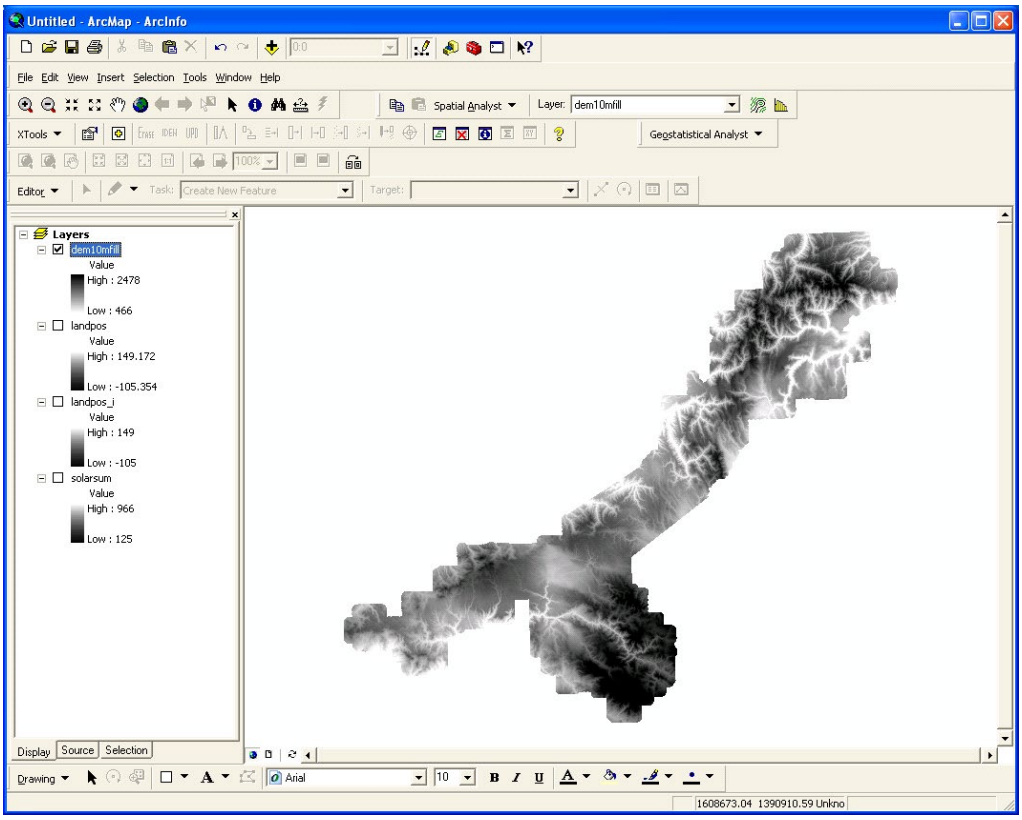


Figure B-3–Example showing ten-meter digital elevation model.

Inclusion of three co-variables allow a sample site density to be described based on its spatial auto-correlation with other points, and to be filtered based upon where in a landscape the point is. For example, a dry site, such as a high elevation SW-facing ridgeline, would have substantially different vegetation composition when compared to a low elevation N-facing coved slope.

Co-kriging analyses were performed for each species individually. Geostatistical Analyst extension allows a user to choose among different semi-variogram models (spherical, exponential, Gaussian, etc.); the model providing a best fit was chosen visually. Modeling output was displayed by classifying filled contours to 100 values (smart quantile method) and choosing Presentation quality (Figure B-6).

ArcGIS offers a direct conversion from model output to Arc/Info grid; this process is time-consuming, taking 24 to 48 hours per model. Because of time constraints, we opted for a different approach, first exporting models to vector files (Figure B-7), and then converting those to grids (Figure B-8). Because of model complexity, this was not possible for western larch, for which the direct conversion from model to grid was used.

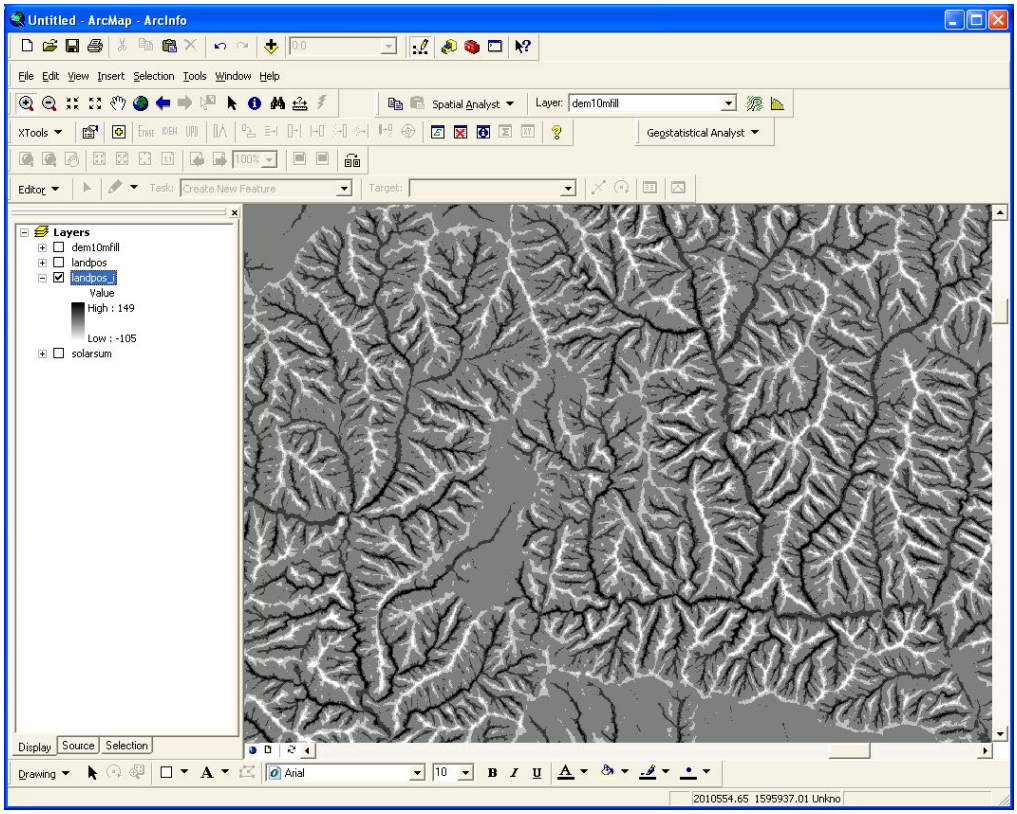


Figure B-4–Example of land position model.

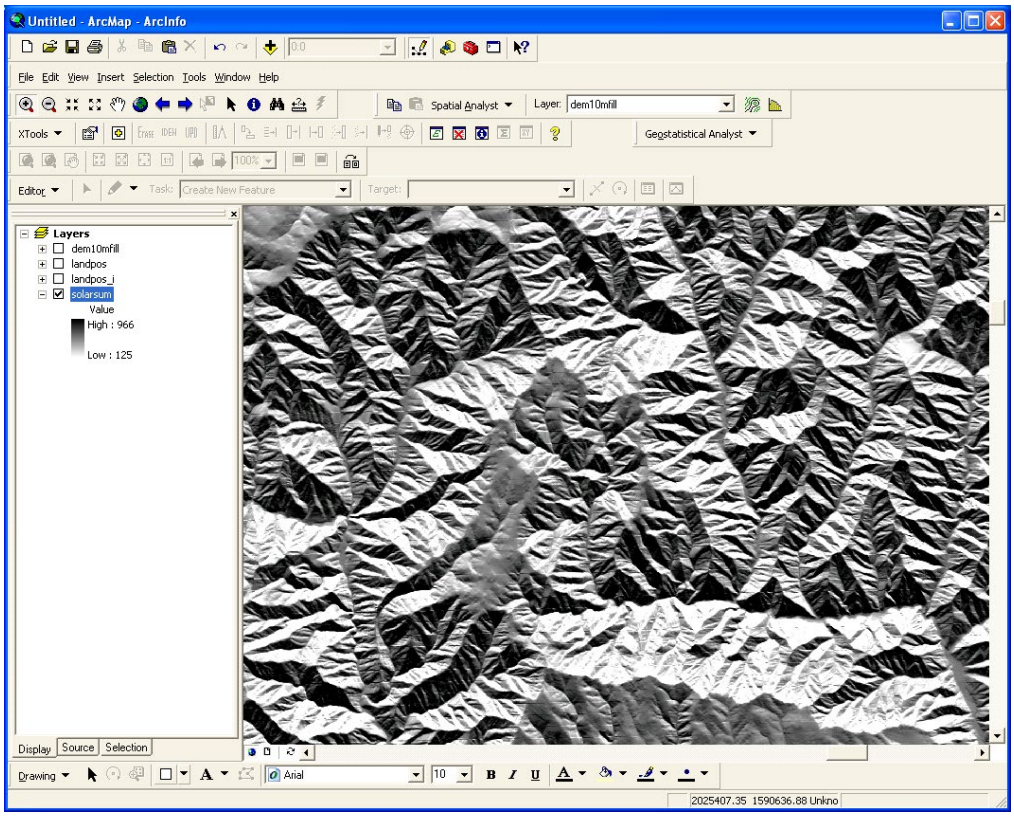


Figure B-5–Example of solar index model.

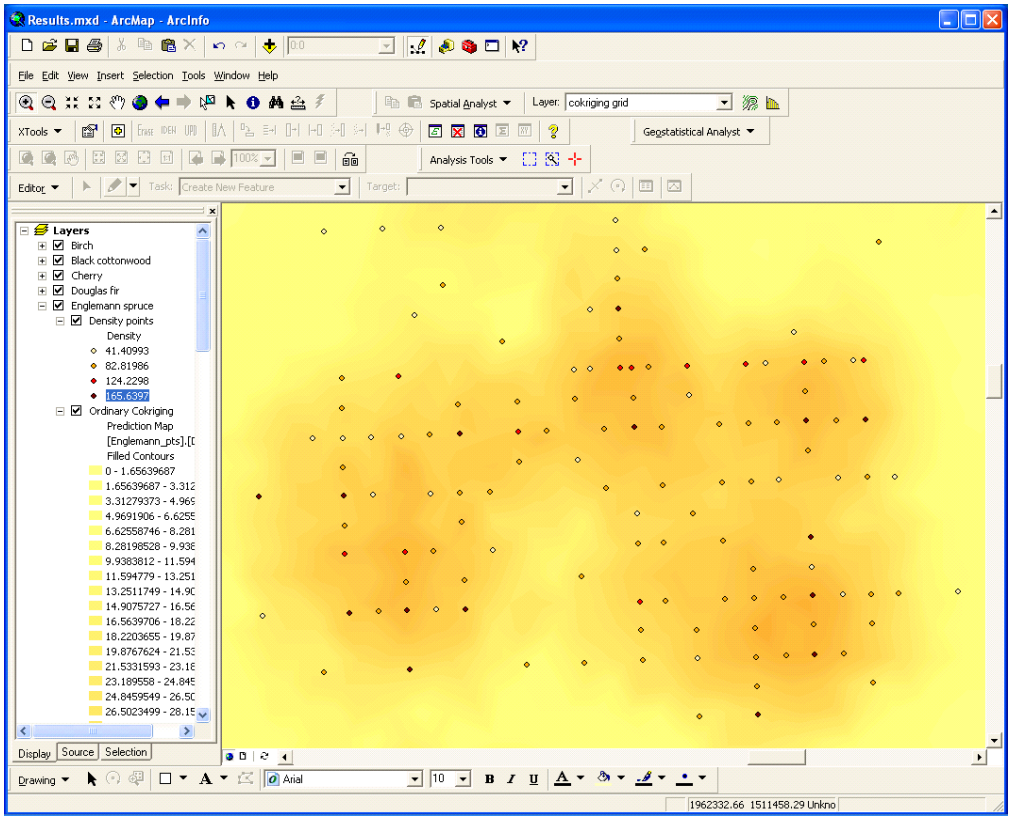


Figure B-6–Example of cokriging model (and density values) for Engelmann spruce.

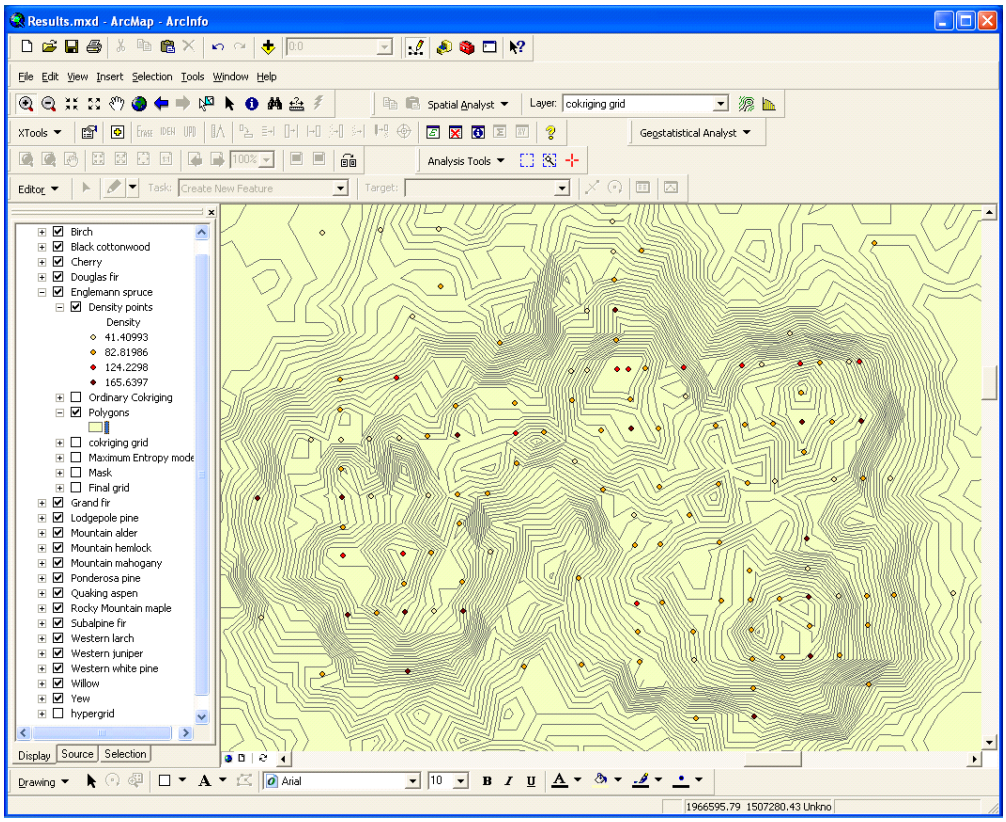


Figure B-7–Example of polygons derived from Engelmann spruce cokriging model.

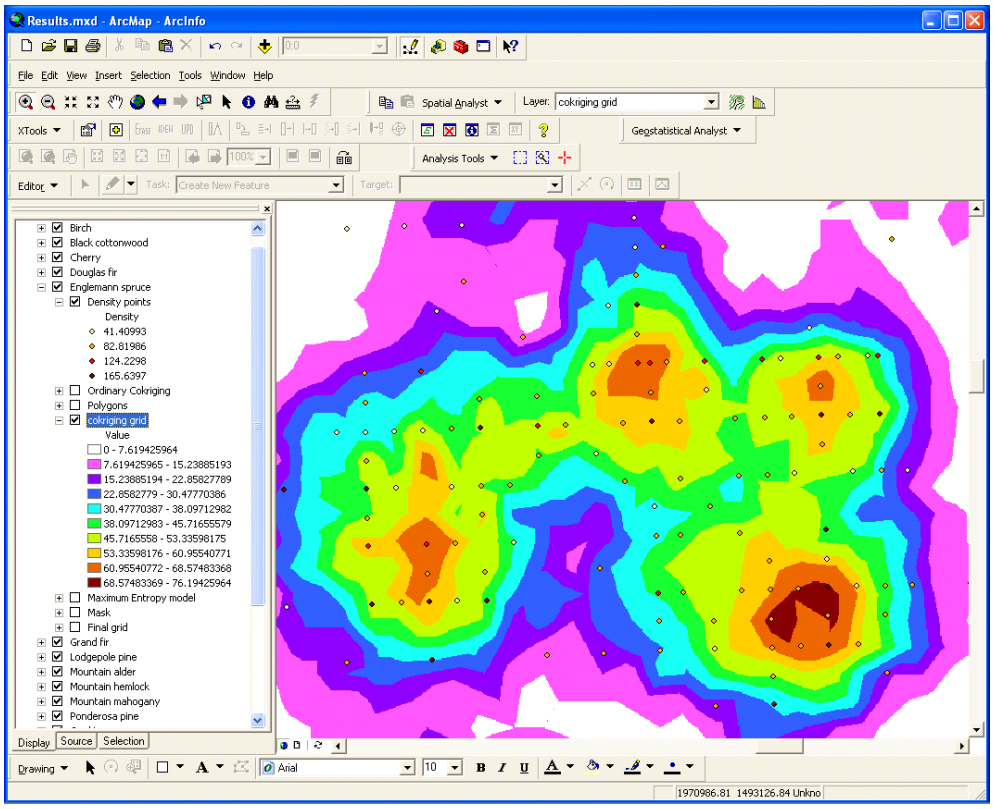


Figure B-8–Example of grid developed from polygon shapefile for Engelmann spruce.

4. Maximum Entropy models

One drawback of CoKriging models is impossibility to limit extent of the model, leading to weird ‘spikes’ where the model extrapolates beyond a range of density points. To limit this problem, environmental models were generated and used as masks over CoKriging models.

Original GLO data were used to extract a file for each species, listing species name, latitude, and longitude of corner points where that species was censused. This file was used as input into a Maximum Entropy model (software MaxEnt.bat from ATTLabs), along with five environmental variables: aspect, elevation, landform, slope, and solar model.

Maximum Entropy was selected over other model types (such as CART or DOMAIN models) because of its better performance with small sample sizes. An overlay with corner trees with model results demonstrates that good results can be obtained, even with only a few corner trees (Figure B-9).

The resulting ASCII file for each species was converted to a floating-point grid and used as a mask over CoKriging grids. Maximum entropy modeling output is probabilistic, i.e., a grid represents distribution of probability of presence of a species; a cut-off probability has to be selected to generate masks.

A cut-off probability was determined in one of two ways. For species with few corner

trees (less than 50), a determination was visual and based on a species' site characteristics, after displaying a grid of probabilities in 10% increments.

Solar model was often displayed in the background as a visual aid. For example, cut-off points for riparian species such as cottonwood or birch were selected to limit distribution to valley bottoms. Entropy model for willow did not limit that species to valley bottoms; a mask of buffered streams was first applied (streams buffered by 1 cell, i.e., 90-m buffer) over the entropy model, and only cokriging cells within that mask, and with a probability value greater than 0, were retained.

For seven remaining species, a probability value was obtained at each point (see table below); cut-off was the probability value above which 75% of points were correctly predicted, with exception of western juniper. The grid was then reclassified and used as a mask over a cokriging model grid (Figure B-10).

Species	**Points**	**75% points**	**Cut-off probability**
Douglas fir	4106	3080	27
Englemann spruce	514	386	28
Grand fir	87	65	30
Lodgepole pine	281	211	33
Ponderosa pine	4516	3387	26
Western juniper	67	60% points = 41	40
Western larch	1406	1055	25
Birch	6		60
Black cottonwood	18		60
Cherry	5		40
Mountain alder	41		50
Mountain hemlock	11		40
Mountain mahogany	11		50
Quaking aspen	6		50
Rocky Mountain maple	8		40
Subalpine fir	4		50
Willow	19		Stream buffer
Yew	8		40

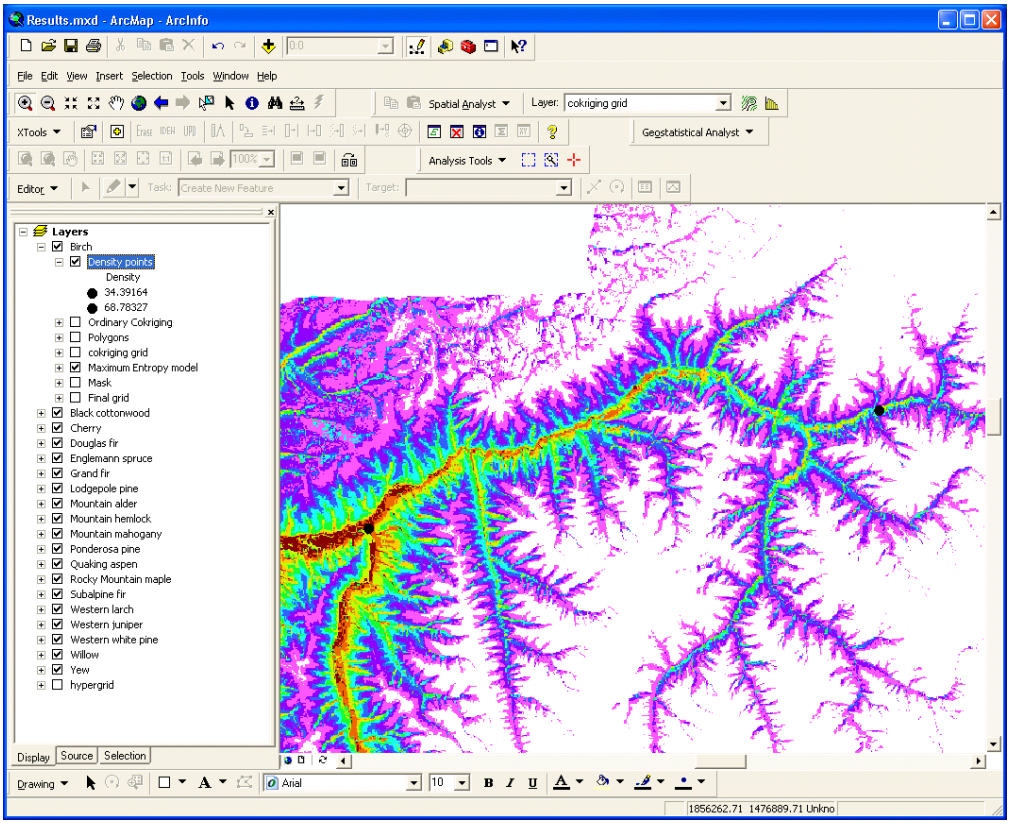


Figure B-9–Example of entropy model for birch.

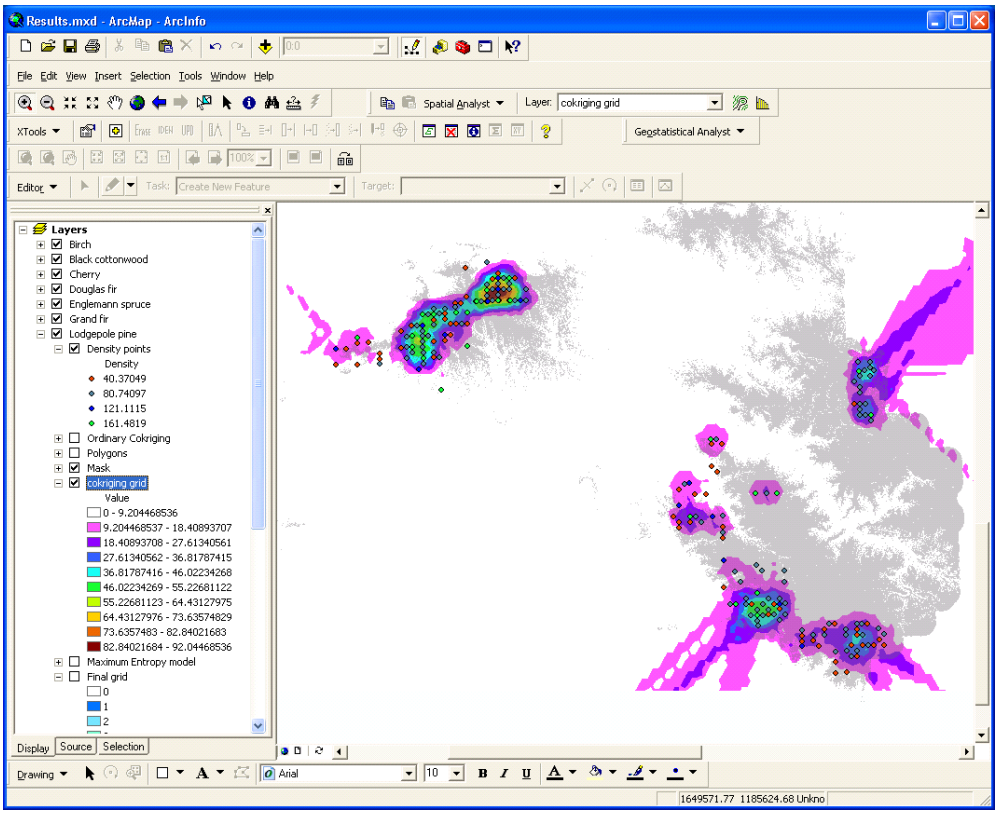


Figure B-10–Example of lodgepole pine cokriging model with maximum entropy mask (gray).

5. Ecological systems grid

To obtain a unique grid of ecological systems, each final cokriging grid was converted to an integer grid, and then reclassified as follows:

Density value	Class
0	0
1-9	1
10-19	2
20-29	3
30-39	4
40-49	5
50-59	6
60-69	7
70-79	8
80-89	9
90-100	10

An Arc/Info aml, originally developed by Jason Karl (Idaho Cooperative Fish & Wildlife Research Unit) for Gap Analysis, was used to combine 18 species grids into a unique 'hypergrid' presenting density classes for each species in column format.

This hypergrid was examined by Jimmy Kagan, who converted combinations of individual species into forest ecological systems (Figure B-11, NatureServe 2003).

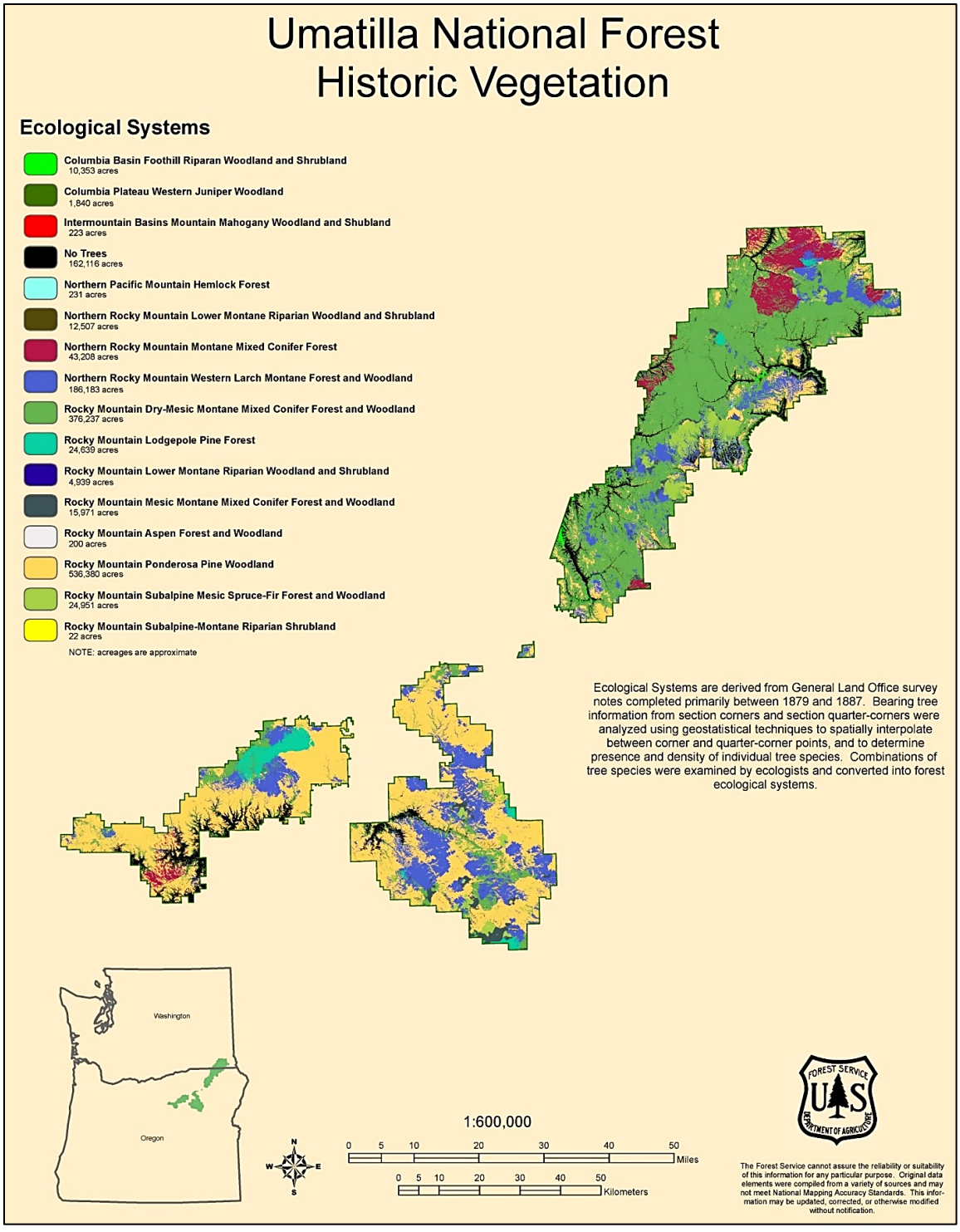


Figure B-11–Final GLO map depicting ecological systems (Comer et al. 2003) within an administrative boundary for Umatilla National Forest, as derived from spatial analyses of GLO survey notes acquired primarily between 1879 and 1887. Appendix B describes analysis process used to generate this map; appendix C describes each ecological system. A larger version of this map (17" × 22" format), and formatted like a poster with supplementary annotations, is available from an Umatilla National Forest History website (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015627.pdf), along with other GLO materials.

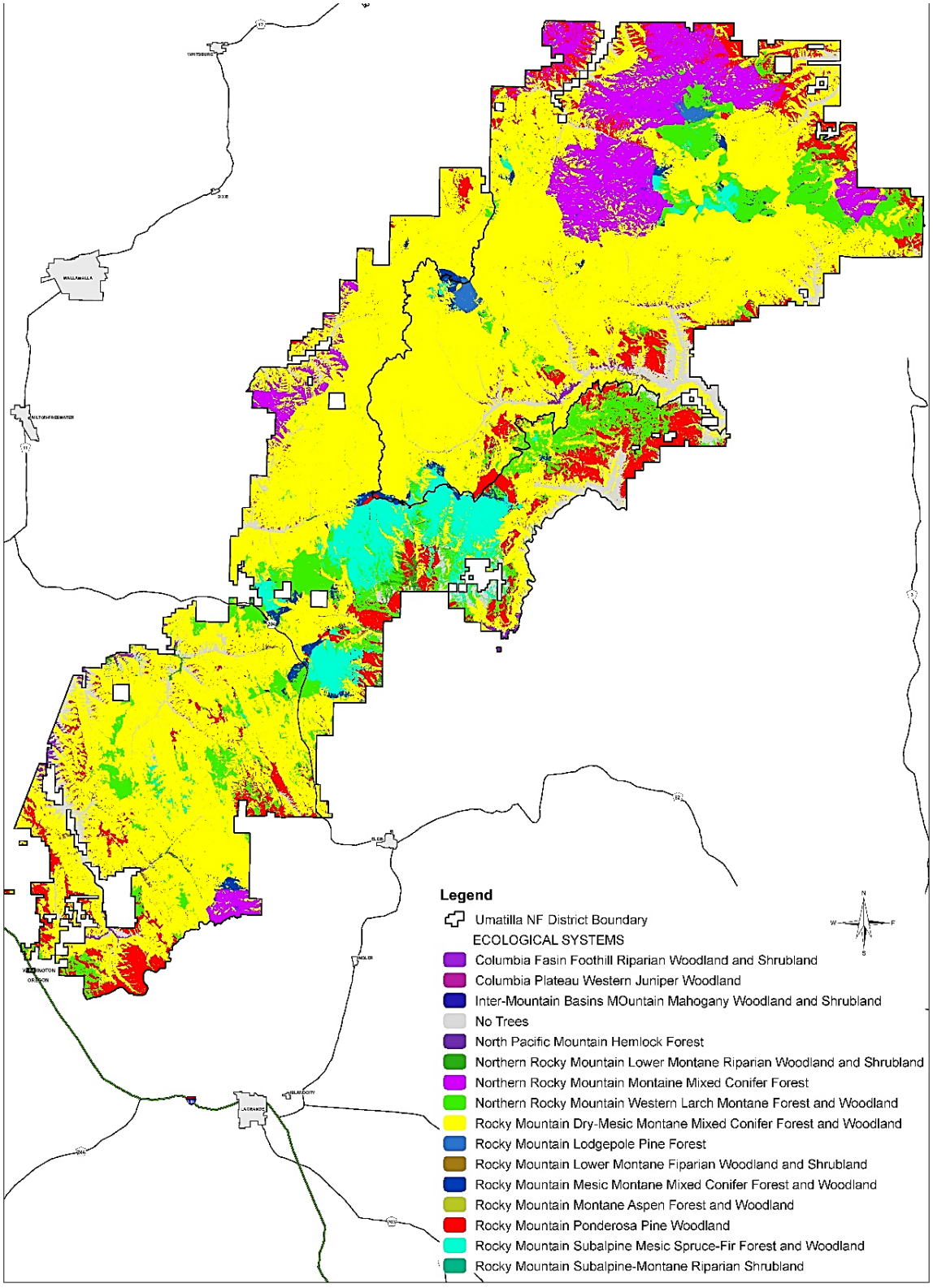


Figure B-12 – Ecological systems for north half of Umatilla NF (Pomeroy & WW districts).

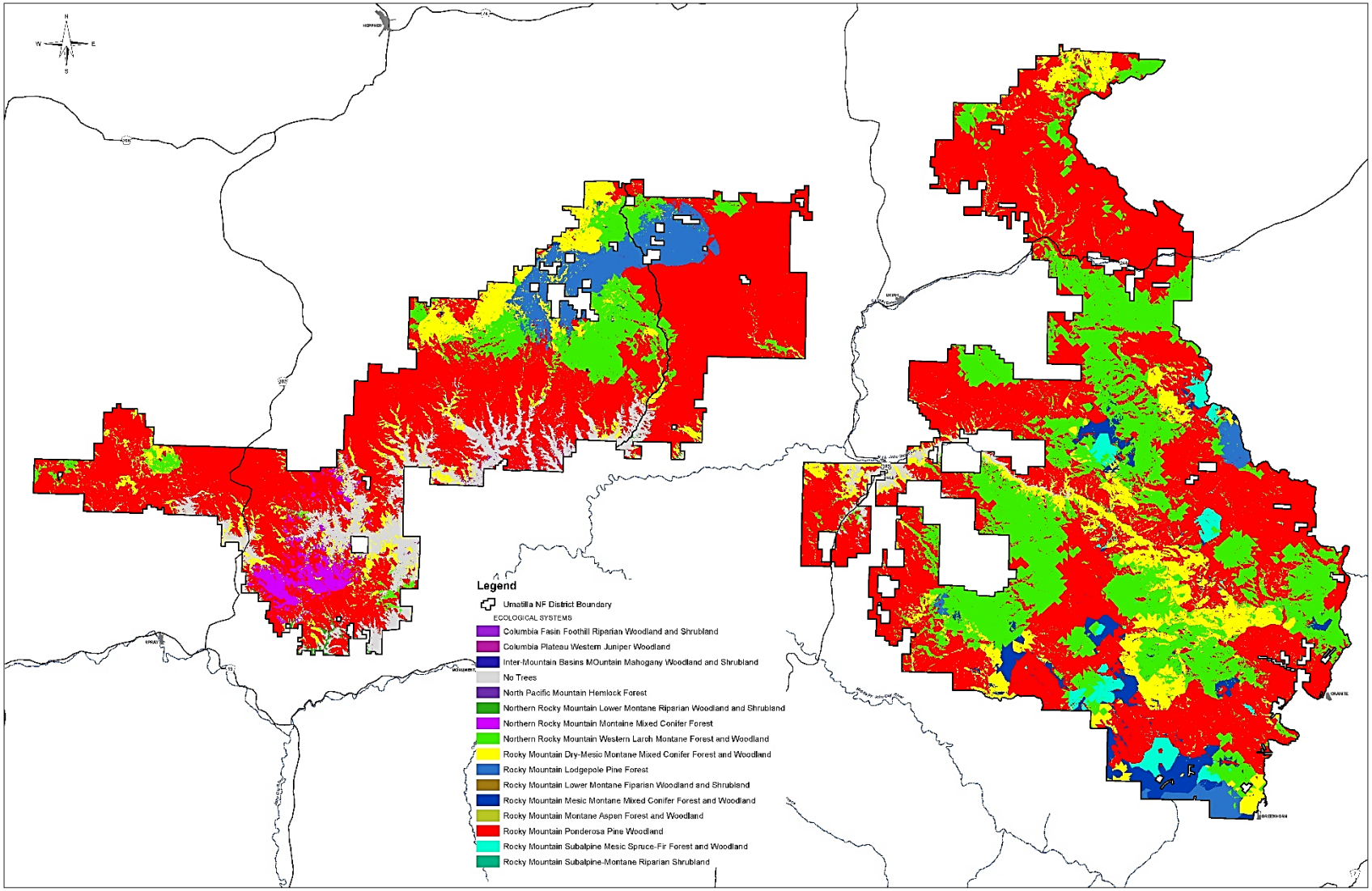


Figure B-13 – Ecological systems for south half of Umatilla National Forest (Heppner and North Fork John Day ranger districts).

APPENDIX C: DESCRIPTION OF ECOLOGICAL SYSTEMS

"Ecological systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding" (Comer et al. 2003).

Umatilla National Forest GLO vegetation map includes 15 different ecological systems, and other ecological systems are believed to exist on the Forest but were too limited to include on the final map.

Descriptions of ecological systems included on an Umatilla NF GLO map were extracted from Natural Heritage Central Databases (NatureServe 2003). Although descriptions are somewhat lengthy, I included them here so that everything related to an ecological systems map (figs. B-11 to B-13) is available from a single source.

Note that unmapped types occurring in Umatilla National Forest are also described in this document, beginning on page 64.

Unmapped types exist on Umatilla NF, when considering other (non-GLO) sources such as plant association classifications and empirical experience, but they occur at a spatial resolution that is too fine to be characterized by GLO survey notes.

In this appendix, information for unmapped ecological systems is presented by using blue text.

Umatilla National Forest Ecological Systems Descriptions

This subset of the Terrestrial Ecological Systems of The United States covers ecological systems attributed to parts of the Pacific Northwest and neighboring interior and mountainous region**.** This classification has been developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications. Comments and suggestions regarding the contents of this subset should be directed to Gwen Kittel, gwen_kittel@natureserve.org.

The following citation should be used in any published materials, which reference these data:
NatureServe. 2003. International Ecological Classification Standard: Terrestrial Ecological Systems of the United States. Natural Heritage Central Databases. NatureServe, Arlington, VA.

NatureServe
1101 Wilson Blvd, 15th floor
Arlington, VA 22209

These data are extracted from:

NatureServe. 2003. International Ecological Classification Standard: Terrestrial Ecological Systems. Natural Heritage Central Databases. NatureServe, Arlington, VA.

This document may be generally cited as follows:

NatureServe[1]. 2003. International Ecological Classification Standard: Terrestrial Ecological Systems of the United States. Natural Heritage Central Databases. NatureServe, Arlington, VA and Natureserve Western Regional Office, Boulder, CO.

[1] NatureServe is an international organization including NatureServe regional offices, a NatureServe central office, U.S. State Natural Heritage Programs, and Conservation Data Centres (CDC) in Canada and Latin America and the Caribbean. Ecologists from the following organizations have contributed the development of the ecological systems classification:

United States
Central NatureServe Office, Arlington, VA; Eastern Regional Office, Boston, MA; Midwestern Regional Office, Minneapolis, MN; Southeastern Regional Office, Durham, NC; Western Regional Office, Boulder, CO; Alabama Natural Heritage Program, Montgomery AL; Alaska Natural Heritage Program, Anchorage, AK; Arizona Heritage Data Management Center, Phoenix AZ; Arkansas Natural Heritage Commission Little Rock, AR; Blue Ridge Parkway, Asheville, NC; California Natural Heritage Program, Sacramento, CA; Colorado Natural Heritage Program, Fort Collins, CO; Connecticut Natural Diversity Database, Hartford, CT; Delaware Natural Heritage Program, Smyrna, DE; District of Columbia Natural Heritage Program/National Capital Region Conservation Data Center, Washington DC; Florida Natural Areas Inventory, Tallahassee, FL; Georgia Natural Heritage Program, Social Circle, GA; Great Smoky Mountains National Park, Gatlinburg, TN; Gulf Islands National Seashore, Gulf Breeze, FL; Hawaii Natural Heritage Program, Honolulu, Hawaii; Idaho Conservation Data Center, Boise, ID; Illinois Natural Heritage Division/Illinois Natural Heritage Database Program, Springfield, IL; Indiana Natural Heritage Data Center, Indianapolis, IN; Iowa Natural Areas Inventory, Des Moines, IA; Kansas Natural Heritage Inventory, Lawrence, KS; Kentucky Natural Heritage Program, Frankfort, KY; Louisiana Natural Heritage Program, Baton Rouge, LA; Maine Natural Areas Program, Augusta, ME; Mammoth Cave National Park, Mammoth Cave, KY; Maryland Wildlife & Heritage Division, Annapolis, MD; Massachusetts Natural Heritage & Endangered Species Program, Westborough, MA; Michigan Natural Features Inventory, Lansing, MI; Minnesota Natural Heritage & Nongame Research and Minnesota County Biological Survey, St. Paul, MN; Mississippi Natural Heritage Program, Jackson, MI; Missouri Natural Heritage Database, Jefferson City, MO; Montana Natural Heritage Program, Helena, MT; National Forest in North Carolina, Asheville, NC; National Forests in Florida, Tallahassee, FL; National Park Service, Southeastern Regional Office, Atlanta, GA; Navajo Natural Heritage Program, Window Rock, AZ; Nebraska Natural Heritage Program, Lincoln, NE; Nevada Natural Heritage Program, Carson City, NV; New Hampshire Natural Heritage Inventory, Concord, NH; New Jersey Natural Heritage Program, Trenton, NJ; New Mexico Natural Heritage Program, Albuquerque , NM; New York Natural Heritage Program, Latham, NY; North Carolina Natural Heritage Program, Raleigh, NC; North Dakota Natural Heritage Inventory, Bismarck, ND; Ohio Natural Heritage Database, Columbus, OH; Oklahoma Natural Heritage Inventory, Norman, OK; Oregon Natural Heritage Program, Portland, OR; Pennsylvania Natural Diversity Inventory, PA; Rhode Island Natural Heritage Program, Providence, RI; South Carolina Heritage Trust, Columbia, SC; South Dakota Natural Heritage Data Base, Pierre, SD; Tennessee Division of Natural Heritage, Nashville, TN; Tennessee Valley Authority Heritage Program, Norris, TN; Texas Conservation Data Center, San Antonio, TX; Utah Natural Heritage Program, Salt Lake City, UT; Vermont Nongame & Natural Heritage Program, Waterbury, VT; Virginia Division of Natural Heritage, Richmond, VA; Washington Natural Heritage Program, Olympia, WA; West Virginia Natural Heritage Program, Elkins, WV; Wisconsin Natural Heritage Program, Madison, WI; Wyoming Natural Diversity Database, Laramie, WY

Canada
Alberta Natural Heritage Information Centre, Edmonton, AB, Canada; Atlantic Canada Conservation Data Centre, Sackville, New Brunswick, Canada; British Columbia Conservation Data Centre, Victoria, BC, Canada; Manitoba Conservation Data Centre. Winnipeg, MB, Canada; Ontario Natural Heritage Information Centre, Peterborough, ON, Canada; Quebec Conservation Data Centre, Quebec, QC, Canada; Saskatchewan Conservation Data Centre, Regina, SK, Canada; Yukon Conservation Data Centre, Yukon, Canada

Latin American and Caribbean
Centro de Datos para la Conservacion de Bolivia, La Paz , Bolivia; Centro de Datos para la Conservacion de Colombia, Cali,Valle, Columbia; Centro de Datos para la Conservacion de Ecuador, Quito, Ecuador; Centro de Datos para la Conservacion de Guatemala, Ciudad de Guatemala , Guatemala; Centro de Datos para la Conservacion de Panama, Querry Heights , Panama; Centro de Datos para la Conservacion de Paraguay, San Lorenzo , Paraguay; Centro de Datos para la Conservacion de Peru, Lima, Peru; Centro de Datos para la Conservacion de Sonora, Hermosillo, Sonora , Mexico; Netherlands Antilles Natural Heritage Program, Curacao , Netherlands Antilles; Puerto Rico-Departmento De Recursos Naturales Y Ambientales, Puerto Rico; Virgin Islands Conservation Data Center, St. Thomas, Virgin Islands.

NatureServe also has partnered with many International and United States Federal and State organizations, which have also contributed significantly to the development of the International Classification. Partners include the following The Nature Conservancy; Provincial Forest Ecosystem Classification Groups in Canada; Canadian Forest Service; Parks Canada; United States Forest Service; National GAP Analysis Program; United States National Park Service; United States Fish and Wildlife Service; United States Geological Survey; United States Department of Defense; Ecological Society of America; Environmental Protection Agency; Natural Resource Conservation Services; United States Department of Energy; and the Tennessee Valley Authority. Many individual state organizations and people from academic institutions have also contributed to the development of this classification.

Executive Summary for Ecological Systems Report

This report presents work conducted to classify and describe terrestrial ecological systems in the coterminous United States and adjacent portions of coastal British Columbia and southern Alaska. A terrestrial ecological system is defined as a group of plant community types (associations) that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. A given terrestrial ecological system will typically manifest itself in a landscape at intermediate geographic scales of 10s to 1,000s of hectares and persist for 50 or more years. Ecological system units are intended to provide "meso-scale" classification units for applications to resource management and conservation. They may serve as practical units on their own or in combination with classification units defined at different conceptual and spatial scales.

Here we define upland and wetland ecological system units emphasizing the "natural" portions of the landscape. We have not defined units for human-dominated areas. The temporal scale or bounds we have chosen integrate typical successional dynamics into the concept of each unit. The spatial characteristics of ecological systems vary on the ground, but all fall into several recognizable and repeatable categories. With these temporal and spatial scales bounding the concept of ecological systems, we may then integrate multiple ecological factors – or *diagnostic classifiers* - to define each classification unit.

Multiple environmental factors are evaluated and combined in different ways to explain the spatial co-occurrence of vegetation associations. Continent-scaled climate, as well as broad patterns in phytogeography, are reflected in Ecological Division units that spatial frame the classification at subcontinental scales. We integrated bioclimatic categories to consistently characterize life zone concepts (e.g. 'maritime,' 'lowland,' 'montane,' 'subalpine,' 'alpine') in appropriate context from arctic through tropical latitudes. Within the context of biogeographic and bioclimatic factors, ecological composition, structure, and function is strongly influenced by factors determined by local physiography, landform, and surface substrate. Some environmental variables are described through existing, standard classifications (e.g. for soil and hydrogeomorphology) and serve as excellent diagnostic classifiers for ecological systems. Many dynamic processes are also sufficiently understood and described to serve as diagnostic classifiers. The recurrent juxtaposition of recognizable vegetation communities provides an additional criterion for multi-factor classification. While biotic turnover, or beta diversity, is a primary consideration in distinguishing among similar ecological system units, the relative abundance of vegetation can also be an important consideration.

Ecological classification ideally proceeds through several phases, including qualitative description, quantitative data gathering, analysis, and field-testing; all in a continual process of refinement. Our approach presented here is qualitative and rule-based, setting the stage for subsequent quantitative work, as well as the development of dichotomous keys and maps. We relied on available interpretations of vegetation and ecosystem patterns across the study area. And we reviewed associations of the IVC/NVC in order to help define the limits of systems concepts. Thus our approach draws extensively on the existing literature available to us. In recent years we have also tested how well a systems approach could facilitate mapping of ecological patterns at intermediate-scales across the landscape. These tests have led to the rule sets and protocols presented here.

This project resulted in the identification and description of 599 upland and wetland ecological system types within the project area. They represent the full range of natural variation, with some 381 types (63%) being uplands, 183 types (31%) being wetland, and 35 types (6%) being complexes of uplands and wetlands. Looking at prevailing vegetation physiognomy, and not counting upland/wetland complexes, some 322 types (54%) are predominantly forest, woodland, and/or shrubland, and some 166 types (28%) are predominantly herbaceous, savanna, or shrub steppe. Seventy-four types (12%) are sparsely vegetated or "barren." All information for this classification is stored in a database, allowing for numerous queries of information on each type.

Terrestrial ecological system units provide practical, systematically defined groupings of plant associations, forming the basis of mapping terrestrial communities and ecosystems at multiple scales of spatial and thematic resolution. Applications of ecological systems include their use as units for conservation assessment, ecological inventory, mapping, land management, ecological monitoring, and species habitat modeling. NatureServe will facilitate ongoing development and refinement of this classification as part of an International Ecological Classification Standard.

Umatilla National Forest Ecological Systems Descriptions

Table of Contents

CES306.828 ROCKY MOUNTAIN SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND

306, Forest and Woodland

Spatial Scale & Pattern: Matrix **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Montane [Upper Montane], Forest and Woodland (Treed), Acidic Soil, Ustic, Very Long Disturbance Interval [Seasonality/Summerr Disturbance], F-Patch/High Intensity, F-Landscape/High Intensity, Needle-Leaved Tree, Abies lasiocarpa - Picea engelmannii, RM Subalpine Mesic Spruce-Fir, Long (> 500 yrs) Persistence

Non-Diagnostic Classifiers: Montane [Montane], Ridge/Summit/Upper Slope, Side Slope, Temperate, Temperate [Temperate Continental], Mesotrophic Soil, Shallow Soil, Mineral: W/ A Horizon >10 cm, W-Patch/Medium Intensity, W-Landscape/Low Intensity

Concept Summary: Engelmann spruce and subalpine fir forests comprise a substantial part of the subalpine forests of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, south into New Mexico and the Inter-mountain region. They are the matrix forests of the subalpine zone, with elevations ranging from 1525 to 3355 m (5,000 to 11,000 feet). Sites within this system are cold year-round, and precipitation is predominantly in the form of snow, which may persist until late summer. Snowpacks are deep and late-lying and summers are cool. Frost is possible almost all summer and may be common in restricted topographic basins and benches. Despite their wide distribution, the tree canopy characteristics are remarkably similar, with *Picea engelmannii* and *Abies lasiocarpa* dominating either mixed or alone. *Pinus contorta* is common in many occurrences and patches of pure *P. contorta* are not uncommon, as well as mixed conifer/*Populus tremuloides* stands. In some areas, such as Wyoming, *Picea engelmannii*-dominated forest are on limestone or dolomite, while nearby co-dominated spruce-fir forests are on granitic or volcanic rocks. Xeric species may include *Juniperus communis, Linnaea borealis, Mahonia repens,* or *Vaccinium scoparium.* Disturbance includes occasional blow-down, insect outbreaks and stand-replacing fire.

DISTRIBUTION

Divisions: 304, 306

TNC Ecoregions: 11:C, 20:C, 21:C, 4:C, 68:C, 7:C, 8:C, 9:C

Subnations/Nations: AB:c, AZ:c, BC:c, CO:c, ID:c, MT:c, NM:c, NV:c, OR:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Abies lasiocarpa - Picea engelmannii Tree Island Forest (GUQ, CEGL000329)
- Abies lasiocarpa / Arnica cordifolia Forest (G5, Subalpine Fir / Heartleaf Arnica Forest, CEGL000298)
- Abies lasiocarpa / Arnica latifolia Forest (G4, CEGL000299)
- Abies lasiocarpa / Calamagrostis rubescens Forest (G4G5, Subalpine Fir / Pinegrass Forest, CEGL000301)
- Abies lasiocarpa / Carex rossii Forest (G4G5, CEGL000305)
- Abies lasiocarpa / Carex siccata Forest (G2, CEGL000303)
- Abies lasiocarpa / Clintonia uniflora Forest (G5, CEGL000307)
- Abies lasiocarpa / Galium triflorum Forest (G4, Subalpine Fir / Sweet-scented Bedstraw Forest, CEGL000311)
- Abies lasiocarpa / Jamesia americana Forest (G1, CEGL000312)
- Abies lasiocarpa / Juniperus communis Woodland (G4G5, Subalpine Fir / Creeping Juniper Woodland, CEGL000919)
- Abies lasiocarpa / Lathyrus lanszwertii var. leucanthus Forest (G3G4, CEGL000313)
- Abies lasiocarpa / Linnaea borealis Forest (G5, Subalpine Fir / Twinflower Forest, CEGL000315)
- Abies lasiocarpa / Mahonia repens Forest (G5, CEGL000318)
- Abies lasiocarpa / Menziesia ferruginea Forest (G5, CEGL000319)
- Abies lasiocarpa / Osmorhiza berteroi Forest (G4, CEGL000323)
- Abies lasiocarpa / Packera sanguisorboides Forest (G3, CEGL000333)
- Abies lasiocarpa / Paxistima myrsinites Woodland (G4, CEGL000324)
- Abies lasiocarpa / Pedicularis racemosa Forest (G5, CEGL000325)
- Abies lasiocarpa / Physocarpus malvaceus Forest (G3, CEGL000326)
- Abies lasiocarpa / Ribes (montigenum, lacustre, inerme) Forest (G5, CEGL000331)
- Abies lasiocarpa / Saxifraga bronchialis Scree Woodland (G4, CEGL000924)
- Abies lasiocarpa / Spiraea betulifolia Forest (G4, CEGL000335)
- Abies lasiocarpa / Symphoricarpos albus Forest (G3, Subalpine Fir / Snowberry Forest, CEGL000337)
- Abies lasiocarpa / Thalictrum occidentale Forest (G4, CEGL000338)

- Abies lasiocarpa / Vaccinium caespitosum Forest (G5, Subalpine Fir / Dwarf Huckleberry Forest, CEGL000340)
- Abies lasiocarpa / Vaccinium membranaceum Forest (G4, CEGL000342)
- Abies lasiocarpa / Vaccinium membranaceum Rocky Mountain Forest (G5, Subalpine Fir / Square-twig Blueberry Forest, CEGL000341)
- Abies lasiocarpa / Vaccinium myrtillus Forest (G5, CEGL000343)
- Abies lasiocarpa / Vaccinium scoparium Forest (G5, CEGL000344)
- Abies lasiocarpa / Xerophyllum tenax Forest (G5, CEGL000346)
- Abies lasiocarpa Krummholz Shrubland (G4, CEGL000985)
- Abies lasiocarpa Scree Woodland (G5?, Subalpine Fir Scree Slope, CEGL000925)
- Picea (engelmannii X glauca, engelmannii) / Clintonia uniflora Forest (G4, CEGL000406)
- Picea (engelmannii X glauca, engelmannii) / Galium triflorum Forest (G4, Spruce / Sweet-scented Bedstraw Forest, CEGL000409)
- Picea (engelmannii X glauca, engelmannii) / Juniperus communis Forest (G2Q, Spruce / Common Juniper Forest, CEGL000410)
- Picea (engelmannii X glauca, engelmannii) / Packera streptanthifolia Forest (G4, Spruce / Cleft-leaf Groundsel Forest, CEGL000414)
- Picea (engelmannii X glauca, engelmannii) / Vaccinium caespitosum Forest (G4, Spruce / Dwarf Huckleberry Forest, CEGL000416)
- Picea engelmannii / Arnica cordifolia Forest (G3G4, CEGL000355)
- Picea engelmannii / Clintonia uniflora Forest (G3, CEGL000360)
- Picea engelmannii / Erigeron eximius Forest (G5, CEGL000364)
- Picea engelmannii / Galium triflorum Forest (G4, CEGL000365)
- Picea engelmannii / Geum rossii Forest (G3?, CEGL000366)
- Picea engelmannii / Juniperus communis Forest (G3, CEGL000369)
- Picea engelmannii / Leymus triticoides Forest (G3, CEGL000362)
- Picea engelmannii / Linnaea borealis Forest (G4, CEGL002689)
- Picea engelmannii / Polemonium pulcherrimum Forest (G5, CEGL000373)
- Picea engelmannii / Ribes montigenum Forest (G5?, CEGL000374)
- Picea engelmannii / Trifolium dasyphyllum Forest (G2?, Engelmann Spruce / Uinta Clover, CEGL000377)
- Picea engelmannii / Vaccinium caespitosum Forest (G4G5, CEGL000378)
- Picea engelmannii / Vaccinium myrtillus Forest (G4Q, CEGL000379)
- Picea engelmannii / Vaccinium scoparium Forest (G3G5, Engelmann Spruce / Grouseberry Forest, CEGL000381)

Dynamics: *Picea engelmannii* can be very long-lived, reaching 500 years of age. *Abies lasiocarpa* decreases in importance relative to *Picea engelmannii* with increasing distance from the region of Montana and Idaho where maritime air masses influence the climate. Fire is an important disturbance factor, but fire regimes have a long return interval and so are often stand-replacing. *Picea engelmannii* can rapidly recolonize and dominate burned sites, or can succeed other species such as *Pinus contorta* or *Populus tremuloides*. Due to great longevity, *Pseudotsuga menziesii* may persist in occurrences of this system for long periods without regeneration. Old-growth characteristics in *Picea engelmannii* forests will include treefall and windthrow gaps in the canopy, with large downed logs, rotting woody material, tree seedling establishment on logs or on mineral soils unearthed in root balls, and snags.

SOURCES

References: Alexander et al. 1984a, Alexander et al. 1987, CanRock 2002, Comer et al. 2002, Cooper et al. 1987, Daubenmire and Daubenmire 1968, DeVelice et al. 1986, Fitzhugh et al. 1987, Graybosch and Buchanan 1983, Hess and Alexander 1986, Hess and Wasser 1982, Hoffman and Alexander 1976, Hoffman and Alexander 1980, Hoffman and Alexander 1983, Komarkova et al. 1988b, Mauk and Henderson 1984, Meidinger and Pojar 1991, Muldavin et al. 1992, Nachlinger et al. 2001, Neely et al. 2001, Pfister 1972, Pfister et al. 1977, Steele and Geier-Hayes 1995, Steele et al. 1981, Tuhy et al. 2002, Youngblood and Mauk 1985

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.820 ROCKY MOUNTAIN LODGEPOLE PINE FOREST

306, Forest and Woodland

Spatial Scale & Pattern: Matrix **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Acidic Soil, Very Shallow Soil, Mineral: W/ A Horizon <10 cm, Ustic, Long Disturbance Interval, F-Patch/High Intensity [Seasonality/Fall Fire], F-Landscape/High Intensity, Needle-Leaved Tree, Pinus contorta, Moderate (100-500 yrs) Persistence

Non-Diagnostic Classifiers: Montane [Upper Montane], Montane [Montane], Forest and Woodland (Treed), Side Slope, Toeslope/Valley Bottom, Temperate, Temperate [Temperate Continental]

Concept Summary: This system is widespread in upper montane to subalpine elevations of the Rocky Mountains, Inter-mountain region, the Eastern Cascades, and north into the Canadian Rockies. These are subalpine forests where the dominance of *Pinus contorta* is related to fire history and topo-edaphic conditions. Following stand-replacing fires, *Pinus contorta* will rapidly colonize and develop into dense, even-aged stands. Most forests in this ecological system are early to mid-successional forests which developed following fires. Some *Pinus contorta* forests will persist on sites that are too extreme for other conifers to establish. These include excessively well-drained pumice deposits, glacial till and alluvium on valley floors where there is cold air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash. Soils supporting these forests are typically well-drained, gravelly, have coarse textures, are acidic, and rarely formed from calcareous parent materials. These forests are dominated by *Pinus contorta* with shrub, grass, or barren understories. Sometimes there are intermingled mixed conifer/*Populus tremuloides* stands with the latter occurring with inclusions of deeper, typically fine-textured soils. The shrub stratum may be conspicuous to absent; common species include *Arctostaphylos uva-ursi, Ceanothus velutinus, Linnaea borealis, Mahonia repens, Purshia tridentata, Spiraea betulifolia, Spiraea douglasii, Shepherdia canadensis, Vaccinium cespitosum, V. scoparium, V. membranaceum, Symphoricarpos albus*, and *Ribes* spp.

DISTRIBUTION

Divisions: 304, 306

TNC Ecoregions: 11:C, 18:C, 20:C, 68:C, 7:C, 8:C, 9:C, 81:c

Subnations/Nations: AB:c, BC:c, CO:c, ID:c, MT:c, NV:c, OR:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Ceanothus velutinus Shrubland (G?, Mountain Balm Shrubland, CEGL002167)
- Pinus contorta / Achnatherum occidentale Woodland (G4Q, CEGL000165)
- Pinus contorta / Arctostaphylos uva-ursi Forest (G5, CEGL000134)
- Pinus contorta / Arnica cordifolia Forest (G4?, Lodgepole Pine / Heartleaf Arnica Forest, CEGL000135)
- Pinus contorta / Artemisia tridentata / Elymus elymoides Woodland (G3, CEGL000137)
- Pinus contorta / Artemisia tridentata / Festuca idahoensis Woodland (G3, CEGL000136)
- Pinus contorta / Calamagrostis rubescens Forest (G5, Lodgepole Pine / Pinegrass Forest, CEGL000139)
- Pinus contorta / Carex geyeri Forest (G4?, CEGL000141)
- Pinus contorta / Carex pensylvanica Forest (G3G4, CEGL000143)
- Pinus contorta / Carex rossii Forest (G5, CEGL000144)
- Pinus contorta / Ceanothus velutinus Forest (G4, CEGL000145)
- Pinus contorta / Danthonia californica Forest (G3Q, CEGL000146)
- Pinus contorta / Festuca idahoensis Woodland (G3, CEGL000149)
- Pinus contorta / Juniperus communis Woodland (G5, Lodgepole Pine / Common Juniper Woodland, CEGL000764)
- Pinus contorta / Linnaea borealis Forest (G5, Lodgepole Pine / Twinflower Forest, CEGL000153)
- Pinus contorta / Mahonia repens Forest (G4G5, CEGL000154)
- Pinus contorta / Osmorhiza berteroi Forest (G3Q, CEGL000155)
- Pinus contorta / Pedicularis racemosa Forest (G2Q, CEGL000156)
- Pinus contorta / Purshia tridentata - Ribes cereum Woodland (G4, CEGL000161)
- Pinus contorta / Purshia tridentata / Carex pensylvanica Forest (G4, CEGL000159)
- Pinus contorta / Purshia tridentata Woodland (G3, CEGL000765)
- Pinus contorta / Shepherdia canadensis Forest (G3G4, CEGL000163)
- Pinus contorta / Spiraea betulifolia Forest (G3G4, CEGL000164)

- Pinus contorta / Spiraea douglasii Forest (G3G4, CEGL002604)
- Pinus contorta / Symphoricarpos albus Forest (G3Q, CEGL000166)
- Pinus contorta / Thalictrum occidentale Forest (G4Q, CEGL000167)
- Pinus contorta / Vaccinium caespitosum Forest (G5, Lodgepole Pine / Dwarf Huckleberry Forest, CEGL000168)
- Pinus contorta / Vaccinium membranaceum Forest (G4?, CEGL000170)
- Pinus contorta / Vaccinium membranaceum Rocky Mountain Forest (G3G4, CEGL000169)
- Pinus contorta / Vaccinium scoparium / Calamagrostis rubescens Forest (G3Q, CEGL000174)
- Pinus contorta / Vaccinium scoparium Forest (G5, Lodgepole Pine / Grouseberry Forest, CEGL000172)
- Pinus contorta / Xerophyllum tenax Forest (G5, CEGL000175)
- Pinus contorta var. latifolia / Purshia tridentata / Achnatherum occidentale ssp. occidentale Woodland (G3, CEGL000162)
- Pinus contorta var. latifolia / Purshia tridentata / Festuca idahoensis Woodland (G3, CEGL000160)
- Pinus contorta var. latifolia / Vaccinium scoparium / Carex inops ssp. inops Forest (G3, CEGL000173)

Dynamics: *Pinus contorta* is an aggressively colonizing, shade-intolerant conifer which usually occurs in lower subalpine forests in the major ranges of the western United States. Establishment is episodic and linked to stand replacing disturbances, primarily fire. The incidence of serotinous cones varies within and between varieties of *Pinus contorta*, being most prevalent in Rocky Mountain populations. Closed, serotinous cones appear to be strongly favored by fire, and allow rapid colonization of fire-cleared substrates (Burns and Honkala 1990a). Hoffman and Alexander (1980, 1983) report that in stands where *Pinus contorta* exhibits a multi-aged population structure, with regeneration occurring, there is typically a higher proportion of trees bearing nonserotinous cones.

SOURCES

References: Alexander 1986, Alexander et al. 1987, Arno et al. 1985, Barrows et al. 1977, Burns and Honkala 1990a, CanRock 2002, Despain 1973a, Despain 1973b, Hess and Wasser 1982, Hoffman and Alexander 1976, Hoffman and Alexander 1980, Johnson and Clausnitzer 1992, Mauk and Henderson 1984, Meidinger and Pojar 1991, Moir 1969a, Nachlinger et al. 2001, Neely et al. 2001, Pfister et al. 1977, Steele et al. 1981, Whipple 1975, Williams and Smith 1990

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.827 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND

306, Forest and Woodland

Spatial Scale & Pattern: Matrix **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Ridge/Summit/Upper Slope, Very Shallow Soil, Mineral: W/ A Horizon <10 cm, Sand Soil Texture, Aridic, Intermediate Disturbance Interval [Perodicity/Polycyclic Disturbance], F-Patch/Medium Intensity, Needle-Leaved Tree, Pinus ponderosa with shrubby understory

Non-Diagnostic Classifiers: Montane [Montane], Montane [Lower Montane], Forest and Woodland (Treed), Temperate, Temperate [Temperate Continental], Circumneutral Soil, F-Landscape/Low Intensity, Short (50-100 yrs) Persistence

Concept Summary: This very widespread ecological system is most common throughout the cordillera of the Rocky Mountains. It is also found in the Colorado Plateau region, west into scattered locations in the Great Basin, and north along the foothills of the Modoc Plateau and Eastern Cascade into southern British Columbia. These woodlands occur at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 500 m in Bristish Columbia to 2800 m in the New Mexico mountains. Occurrences are found on all slopes and aspects, however moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on igneous, metamorphic, and sedimentary material derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acid pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. These woodlands in the eastern Cascades, Okanagan and northern Rockies regions receive winterand spring rains, and thus have a greater spring "green-up" than the drier woodlands in the central Rockies. *Pinus ponderosa* is the predominant conifer; *Pseudotsuga menziesii, Pinus edulis*, and *Juniperus* spp. may be present in the tree canopy. The understory is usually shrubby, with *Artemisia nova, A. tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus montanus, C. ledifolius, Purshia stansburiana, P. tridentata, Quercus*

gambelii, Symphoricarpos oreophilus, Prunus virginiana, Amelanchier alnifolia, and *Rosa* spp. common species. *Pseudoreogneria spicata* and species of *Hesperostima, Achnatherum, Festuca, Muhlenbergia* and *Bouteloua* are some of the common grasses. Mixed fire regimes and ground fires of variable return interval maintain these woodlands, depending on climate, degree of soil development, and understory density.

Comments: This system intergrades with the Rocky Mountain Ponderosa Pine Savanna system. They are distiguished by the high frequency, surface-fire regime, less steep or rocky environmental setting, and more open grassy understory structure of the Savanna system.

DISTRIBUTION

Divisions: 204, 304, 306
TNC Ecoregions: 10:C, 11:C, 18:C, 19:C, 20:C, 21:C, 25:C, 26:C, 4:C, 6:C, 68:C, 7:C, 8:C, 9:C
Subnations/Nations: AB:c, AZ:c, BC:c, CO:c, ID:c, MT:c, NM:c, NV:c, OR:c, SD:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Pinus ponderosa - Pinus strobiformis Forest (G2?, CEGL007091)
- Pinus ponderosa / Amelanchier alnifolia Woodland (G2, Ponderosa Pine / Serviceberry Woodland, CEGL000840)
- Pinus ponderosa / Arctostaphylos patula - Arctostaphylos viscida Forest (G2Q, CEGL000061)
- Pinus ponderosa / Arctostaphylos patula - Ceanothus velutinus Woodland (G1, CEGL000062)
- Pinus ponderosa / Arctostaphylos patula - Purshia tridentata Woodland (G3, CEGL000063)
- Pinus ponderosa / Arctostaphylos patula Woodland (G5, CEGL000842)
- Pinus ponderosa / Arctostaphylos pungens Woodland (G3, CEGL000843)
- Pinus ponderosa / Arctostaphylos uva-ursi Woodland (G4, Ponderosa Pine / Bearberry Woodland, CEGL000844)
- Pinus ponderosa / Artemisia arbuscula Woodland (G2G3Q, CEGL000845)
- Pinus ponderosa / Artemisia nova Woodland (G5, CEGL000846)
- Pinus ponderosa / Artemisia tridentata - Purshia tridentata Woodland (G3, CEGL000178)
- Pinus ponderosa / Artemisia tridentata ssp. vaseyana / Poa nervosa Woodland (G2G3, CEGL000180)
- Pinus ponderosa / Artemisia tridentata ssp. wyomingensis / Hesperostipa comata Woodland (G1, CEGL000179)
- Pinus ponderosa / Bouteloua gracilis Woodland (G4, Ponderosa Pine / Blue Grama Woodland, CEGL000848)
- Pinus ponderosa / Bromus inermis Semi-natural Woodland (G?, CEGL002943)
- Pinus ponderosa / Calamagrostis rubescens Forest (G2Q, Ponderosa Pine / Pinegrass Forest, CEGL000181)
- Pinus ponderosa / Carex geyeri Woodland (G3G4, Ponderosa Pine / Elk Sedge Woodland, CEGL000182)
- Pinus ponderosa / Carex inops ssp. heliophila Woodland (G3G4, Ponderosa Pine / Sedge Woodland, CEGL000849)
- Pinus ponderosa / Carex rossii Forest (G4G5, Ponderosa Pine / Ross' Sedge Forest, CEGL000183)
- Pinus ponderosa / Ceanothus velutinus - Purshia tridentata Woodland (G4, CEGL000064)
- Pinus ponderosa / Cercocarpus ledifolius Woodland (G4, CEGL000850)
- Pinus ponderosa / Cercocarpus montanus Woodland (G4, Ponderosa Pine / Mountain-mahogany Woodland, CEGL000851)
- Pinus ponderosa / Elymus glaucus Forest (G2, CEGL000184)
- Pinus ponderosa / Fallugia paradoxa Woodland (G?, CEGL002999)
- Pinus ponderosa / Festuca arizonica Woodland (G4, CEGL000856)
- Pinus ponderosa / Festuca campestris Woodland (G3G4, Ponderosa Pine / Rough Fescue Forest, CEGL000185)
- Pinus ponderosa / Festuca idahoensis Woodland (G4, Ponderosa Pine / Idaho Fescue Woodland, CEGL000857)
- Pinus ponderosa / Hesperostipa comata Woodland (G1, CEGL000879)
- Pinus ponderosa / Juniperus communis Woodland (G4?, Ponderosa Pine / Common Juniper Woodland, CEGL000859)
- Pinus ponderosa / Juniperus horizontalis Woodland (G3?, Ponderosa Pine / Creeping Juniper Woodland, CEGL000860)
- Pinus ponderosa / Juniperus scopulorum Woodland (G4, Ponderosa Pine / Rocky Mountain Juniper Woodland, CEGL000861)
- Pinus ponderosa / Leucopoa kingii Woodland (G3, CEGL000186)
- Pinus ponderosa / Mahonia repens Forest (G3Q, Ponderosa Pine / Oregon Grape Forest, CEGL000187)
- Pinus ponderosa / Muhlenbergia montana Woodland (G4G5, CEGL000862)
- Pinus ponderosa / Muhlenbergia virescens - Festuca arizonica Woodland (G5?, CEGL000864)
- Pinus ponderosa / Muhlenbergia virescens Woodland (G5, CEGL000863)

- Pinus ponderosa / Oryzopsis asperifolia Woodland (G3G4Q, Ponderosa Pine / Rough-leaf Ricegrass Woodland, CEGL002123)
- Pinus ponderosa / Pascopyrum smithii Woodland (G3G4, Ponderosa Pine / Western Wheatgrass Woodland, CEGL000188)
- Pinus ponderosa / Physocarpus malvaceus Forest (G2, CEGL000189)
- Pinus ponderosa / Physocarpus monogynus Forest (G3, Ponderosa Pine / Mountain Ninebark Forest, CEGL000190)
- Pinus ponderosa / Prunus virginiana Forest (G3G4, Ponderosa Pine / Chokecherry Forest, CEGL000192)
- Pinus ponderosa / Pseudoroegneria spicata Woodland (G4, Ponderosa Pine / Bluebunch Wheatgrass Woodland, CEGL000865)
- Pinus ponderosa / Pteridium aquilinum Woodland [Provisional] (G?, CEGL002944)
- Pinus ponderosa / Purshia stansburiana Woodland (G3, CEGL000854)
- Pinus ponderosa / Purshia tridentata / Achnatherum hymenoides Woodland (G1, Ponderosa Pine / Antelope Bitterbrush / Indian Ricegrass Woodland, CEGL000196)
- Pinus ponderosa / Purshia tridentata / Carex geyeri Woodland (G3, CEGL002606)
- Pinus ponderosa / Purshia tridentata / Carex rossii Woodland (G2G3, CEGL000194)
- Pinus ponderosa / Purshia tridentata / Festuca idahoensis Woodland (G3, CEGL000195)
- Pinus ponderosa / Purshia tridentata / Pseudoroegneria spicata Woodland (G3, CEGL000197)
- Pinus ponderosa / Purshia tridentata Woodland (G3G5, CEGL000867)
- Pinus ponderosa / Quercus gambelii Woodland (G5, CEGL000870)
- Pinus ponderosa / Quercus macrocarpa Woodland (G3, Ponderosa Pine / Bur Oak Woodland, CEGL000873)
- Pinus ponderosa / Quercus X pauciloba Woodland (G5, Ponderosa Pine / Wavyleaf Oak Woodland, CEGL000874)
- Pinus ponderosa / Ribes cereum Forest (GU, CEGL000199)
- Pinus ponderosa / Ribes inerme Scree Woodland (G4, CEGL000876)
- Pinus ponderosa / Rockland Woodland (G5?, Ponderosa Pine Rockland Woodland, CEGL000877)
- Pinus ponderosa / Schizachyrium scoparium Woodland (G3G4, Ponderosa Pine / Little Bluestem Woodland, CEGL000201)
- Pinus ponderosa / Spiraea betulifolia Forest (G1G2, Ponderosa Pine / Shiny-leaf Spiraea Forest, CEGL000202)
- Pinus ponderosa / Symphoricarpos albus Forest (G4?, Ponderosa Pine / Snowberry Forest, CEGL000203)
- Pinus ponderosa / Symphoricarpos occidentalis Forest (G3, Ponderosa Pine / Wolfberry Forest, CEGL000204)
- Pinus ponderosa / Symphoricarpos oreophilus Forest (G3, CEGL000205)
- Pinus ponderosa Scree Woodland (G4, Ponderosa Pine Scree Woodland, CEGL000878)

Environment: This ecological system within the region occurs at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites at elevations ranging from 1980 - 2800 m. (6500 - 9200 feet). It can occur on all slopes and aspects, however it commonly occurs on moderately steep to very steep slopes or ridgetops. This ecological system generally occurs on igneous, metamorphic, and sedimentary material derived soils, including basalt, basaltic, andesitic flows, intrusive granitoids and porphyrites, and tuffs (Youngblood and Mauk 1985). Characteristic soil features include good aeration and drainage, coarse textures, circumneutral to slightly acid pH, an abundance of mineral material, and periods of drought during the growing season. Some occurrences may occur as edaphic climax communities on very skeletal, infertile, and/or excessively drained soils, such as pumice, cinder or lava fields, and scree slopes.

Surface textures are highly variable in this ecological system ranging from sand to loam and silt loam. Exposed rock and bare soil consistently occur to some degree in all the associations. *Pinus ponderosa / Arctostaphylos patula* represents the extreme with typically a high percent of rock and bare soil present.

Precipitation generally contributes 25 - 60 cm annually to this system, mostly through winter storms and some monsoonal summer rains. Typically a seasonal drought period occurs throughout this system as well. Fire plays and important role in maintaining the characteristics of these open canopy woodlands. However, soil infertility and drought may contribute significantly in some areas as well.

Dynamics: *Pinus ponderosa* is a drought resistant, shade-intolerant conifer which usually occurs at lower treeline in the major ranges of the western United States. Historically, ground fires and drought were influential in maintaining open canopy conditions in these woodlands. With settlement and subsequent fire suppression, occurrences have become denser. Presently, many occurrences contain under-stories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa*. These altered occurrence structures have affected fuel loads and alter fire regimes. Pre-settlement fire regimes were primarily

frequent (5-15 year return intervals), low intensity ground fires triggered by lightning strikes or deliberately set fires by Native Americans. With fire suppression and increased fuel loads, fire regimes are now less frequent and often become intense crown fires, which can kill mature *Pinus ponderosa* (Reid et al. 1999).

Establishment is erratic and believed to be linked to periods of adequate soil moisture and good seed crops as well as fire frequencies, which allow seedlings to reach sapling size. Longer fire intervals have resulted in many occurrences having dense sub-canopies of overstocked and unhealthy young *Pinus ponderosa* (Reid et al. 1999).

Mehl (1992) states the following: Where fire has been present, occurrences will be climax and contain groups of large, old trees with little understory vegetation or down woody material and few occurring dead trees. The age difference of the groups of trees would be large. Where fire is less frequent there will also be smaller size trees in the understory giving the occurrence some structure with various canopy layers. Dead, down material will be present in varying amounts along with some occurring dead trees. In both cases the large old trees will have irregular open, large branched crowns. The bark will be lighter in color, almost yellow, thick and some will like have basal fire scars.

Grace's warbler, Pygmy nuthatch, and flammulated owl are indicators of a healthy ponderosa pine woodland. All of these birds prefer mature trees in an open woodland setting (Winn 1998, Jones 1998, Levad 1998 as cited in Rondeau 2001).

SOURCES

References: CanRock 2002, Comer et al. 2002, Cooper et al. 1987, Daubenmire and Daubenmire 1968, DeVelice et al. 1986, Hess and Alexander 1986, Hoffman and Alexander 1976, Komarkova et al. 1988b, Marriott and Faber-Langendoen 2000, Mauk and Henderson 1984, Mehl 1992, Meidinger and Pojar 1991, Muldavin et al. 1987, Muldavin et al. 1996, Nachlinger et al. 2001, Neely et al. 2001, Pfister et al. 1977, Reid et al. 1999, Rondeau 2001, Tuhy et al. 2002, Youngblood and Mauk 1985

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.826 ROCKY MOUNTAIN PONDEROSA PINE SAVANNA

306, Steppe/Savanna

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Woody-Herbaceous, Shallow Soil, Aridic, Short Disturbance Interval, F-Patch/Low Intensity, F-Landscape/Low Intensity, Needle-Leaved Tree, Graminoid, Pinus ponderosa with grassy understory

Non-Diagnostic Classifiers: Montane [Montane], Montane [Lower Montane], Lowland [Foothill], Temperate [Temperate Continental], Mineral: W/ A Horizon <10 cm, Sand Soil Texture, Short (50-100 yrs) Persistence

Concept Summary: This ecological system occurs throughout the inland portions of western North America, primarily in the foothills and montane zones from approximately a low elevation of 335 m in southern British Columbia, including the lower edges of Ponderosa Pine in the East Cascades and Modoc Plateau, to well over 2,700 m on the higher plateaus of the southwest. It is found on rolling plains, plateaus, or dry slopes usually on more southerly aspects. This system is best described as a savanna that has widely spaced (>150 years old) *Pinus ponderosa*. It is maintained by a fire regime of frequent, low-intensity surface fires. A healthy occurrence often consists of open and park-like stands dominated by *Pinus ponderosa*. Understory vegetation in the true savanna occurrences is predominantly fire-resistant grasses and forbs that resprout following surface fires; shrubs, understory trees and downed logs are uncommon. Important species include *Festuca arizonica, Pseudoroegneria spicata, Andropogon gerardii, Schizachyrium scoparium, Festuca* spp. and *Bouteloua gracilis*. A century of anthropogenic disturbance and fire suppression has resulted in a higher density of *Pinus ponderosa* trees, altering the fire regime and species composition. Presently, many stands contain understories of more shade-tolerant species, such as *Pseudotsuga menziesii* and/or *Abies* spp., as well as younger cohorts of *Pinus ponderosa.*

DISTRIBUTION

Divisions: 303, 304, 306

TNC Ecoregions: 20:C, 21:C, 25:C, 6:C, 68:C, 8:C

Subnations/Nations: AZ:c, BC:c, CO:c, ID:p, MT:p, NM:c, NV:p, OR:c, SD:c, UT:p, WA:c, WY:c

CONCEPT

Associations:

- Pinus ponderosa / (Andropogon gerardii, Schizachyrium scoparium) Woodland (G2Q, Ponderosa Pine / Bluestem Woodland, CEGL000841)
- Pinus ponderosa / Bouteloua gracilis Woodland (G4, Ponderosa Pine / Blue Grama Woodland, CEGL000848)
- Pinus ponderosa / Calamagrostis rubescens Forest (G2Q, Ponderosa Pine / Pinegrass Forest, CEGL000181)
- Pinus ponderosa / Cercocarpus montanus / Andropogon gerardii Wooded Herbaceous Vegetation (G2, Ponderosa Pine / Mountain-mahogany / Big Bluestem, CEGL000852)
- Pinus ponderosa / Festuca arizonica Woodland (G4, CEGL000856)
- Pinus ponderosa / Festuca campestris Woodland (G3G4, Ponderosa Pine / Rough Fescue Forest, CEGL000185)
- Pinus ponderosa / Festuca idahoensis Woodland (G4, Ponderosa Pine / Idaho Fescue Woodland, CEGL000857)
- Pinus ponderosa / Muhlenbergia virescens - Festuca arizonica Woodland (G5?, CEGL000864)
- Pinus ponderosa / Muhlenbergia virescens Woodland (G5, CEGL000863)
- Pinus ponderosa / Pseudoroegneria spicata Woodland (G4, Ponderosa Pine / Bluebunch Wheatgrass Woodland, CEGL000865)
- Pinus ponderosa / Schizachyrium scoparium Woodland (G3G4, Ponderosa Pine / Little Bluestem Woodland, CEGL000201)

SOURCES

References: Meidinger and Pojar 1991

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.NEW NORTHERN ROCKY MOUNTAIN WESTERN LARCH WOODLAND AND FORESTS

306, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Forest and Woodland (Treed), Udic, F-Landscape/Medium Intensity, Needle-Leaved Tree, Larix occidentalis dominance or co-dominance, Long (> 150 yrs)Long (> 500 yrs)

Non-Diagnostic Classifiers: Alpine/AltiAndino, Cirque, Cirque headwall, Temperate, Temperate [Temperate Continental], Glaciated , Very Short Disturbance Interval [Periodicity/Nonrandom Disturbance]

Concept Summary: Concept Summary: This ecological system occurs as a large patch type within the variation of the defined Rocky Montane Dry Mesic Mixed Conifer System. As its own system, it is a large patch type restricted to the interior montane forests of the Pacific Northwest. This ecological system is found in the interior Pacific Northwest in northern Idaho and adjacent Montana, Washington, Oregon and in southeast interior British Columbia. It also appears in the east Cascades of Washington. The deciduous conifer *Larex occidentalis* is dominant or co-dominant (over 50% of total canopy cover, or the dominant conifer in mixed conifer stands) with evergreen conifers trees, usually *Pseudotsuga menziesii* and *Pinus ponderosa*. These stands initate following crown fires in areas with stand replacing fire-frequency greater than 150 years. Low intensity/frequency fire creates open larch woodlands often with undergrowth dominated by *Calamagrostis rubescens*, *Festuca idahoensis,* and sometimes low deciduous shrubs (*Spiraea betuloides* or *Symphoricarpos albus*. Less frequent or absense of fire creates mixed dominance stands with often shrubby undergrowth. Most occurrences of this system are dominated by a mix of *Pseudotsuga menziesii, Pinus contorta* or *P monticola* with lesser amounts of *Abies grandis* or *Abies lasiocarpa*. Winter snow packs typically melt off in early spring at lower elevation sites. Elevations range from 1000-2500 m.

DISTRIBUTION

Divisions: 204

TNC Ecoregions: ??

Subnations/Nations: OR:c, WA:c, ID:c. MT:c, BC:?

CONCEPT

Associations:

PSME/VACA LILLYBRIDGE ET AL 1995 3 PLOTS PICO(29%)-LAOC(22%)-PSME(22%) – NOTE – THIS TYPE WAS VERY COMMON HISTORICALLY, BUT CURRENTLY IS VERY RESTRICTED, SO ASSOCIATIONS HAVE NOT BEEN WELL DESCRIBED.

SOURCES

References: Hessburg, et al 2000; Hessburg et al 1999, Agee 1993
Last updated: 20 Feb 2003 **Stakeholders:** WCS, CAN
Concept Author: Rex Crawford and Jimmy Kagan **LeadResp:** WCS

CES304.771 COLUMBIA PLATEAU WESTERN JUNIPER WOODLAND

304, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** low
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Montane [Lower Montane], Lowland [Foothill], Forest and Woodland (Treed), Ridge/Summit/Upper Slope, Aridic

Non-Diagnostic Classifiers: Foothill(s), Piedmont, Plateau, Side Slope, Temperate [Temperate Continental], Alkaline Soil, Long Disturbance Interval, F-Patch/Medium Intensity, Juniperus occidentalis

Concept Summary: This woodland system is found along the northern and western margins of the Great Basin, from southwestern Idaho, along the eastern foothills of the Cascades, south to the Modoc Plateau of northeast California. Elevations range from under 200 m along the Columbia River in central Washington to over 1500 m. Generally soils are medium-textured, with abundant coarse fragments, and derived from volcanic parent materials. In central Oregon, the center of distribution, all aspects and slope positions occur. Where this system grades into relatively mesic forest or grassland habitats, these woodlands become restricted to rock outcrops or escarpments with excessively drained soils. *Pinus monophylla* is not present in this region, so *Juniperus occidentalis* is the only tree species, although *Pinus ponderosa* or *P. jeffreyi* may be present in some stands. *Cercocarpus ledifolius* may occasionally codominate. *Artemisia tridentata* is the most common shrub; others are *Purshia tridentata, Ericameria nauseosa, Chrysothamnus viscidiflorus, Ribes cereum,* and *Tetradymia* spp. Graminoids include *Carex filifolia, Festuca idahoensis, Poa secunda* and *Pseudoroegneria spicata*. These woodlands are generally restricted to rocky areas where fire frequency is low. Throughout much of its range, fire suppression and removal of fine fuels by grazing livestock has reduce fire frequency to allow *Juniperus occidentalis* seedlings to colonize adjacent alluvial soils and expend into the shrub steppe and grasslands. *Juniper occidentalis* savanna may occur on the drier edges of the woodland where trees are intermingling with or invading the surrounding grasslands, and where local edaphic or climatic conditions favor grasslands over shrublands.

Comments: These woodlands are composed of two very different types. There are old-growth *Juniperus occidentalis* woodlands with trees and stands often over 1000 years old, with fairly well-spaced trees with rounded crowns. There are also large areas where juniper has expanded into sagebrush steppe and bunchgrass dominated areas, with young, pointed crowned trees growing closely together. Currently, these two very different types are about equally distributed across the landscape, with *Juniperus occidentalis* continuing to expand, either from fire supression, grazing or climate change.

DISTRIBUTION

Divisions: 304
TNC Ecoregions: 6:C, 68:C, 7:C
Subnations/Nations: ID:c, NV:c, OR:c, WA:c

CONCEPT

Associations:

- Juniperus occidentalis / Achnatherum thurberianum Woodland (G2, CEGL002635)
- Juniperus occidentalis / Artemisia arbuscula / Festuca idahoensis Wooded Herbaceous Vegetation (G3?, CEGL001716)
- Juniperus occidentalis / Artemisia arbuscula / Poa secunda Wooded Herbaceous Vegetation (G2, CEGL001715)
- Juniperus occidentalis / Artemisia arbuscula / Pseudoroegneria spicata Wooded Herbaceous Vegetation (G3G4, CEGL001717)

- Juniperus occidentalis / Artemisia rigida / Poa secunda Wooded Herbaceous Vegetation (G2G3, CEGL001718)
- Juniperus occidentalis / Artemisia tridentata - Purshia tridentata Wooded Herbaceous Vegetation (G4Q, CEGL001722)
- Juniperus occidentalis / Artemisia tridentata / Carex filifolia Wooded Herbaceous Vegetation (G1, Western Juniper / Big Sagebrush / Threadleaf Sedge, CEGL001719)
- Juniperus occidentalis / Artemisia tridentata / Festuca idahoensis Wooded Herbaceous Vegetation (G3, CEGL001720)
- Juniperus occidentalis / Artemisia tridentata / Pseudoroegneria spicata Wooded Herbaceous Vegetation (G3G4, CEGL001721)
- Juniperus occidentalis / Artemisia tridentata ssp. vaseyana Woodland (G4, CEGL000723)
- Juniperus occidentalis / Cercocarpus ledifolius - Symphoricarpos oreophilus Woodland (G2, CEGL000726)
- Juniperus occidentalis / Cercocarpus ledifolius / Carex geyeri Wooded Herbaceous Vegetation (G2, Western Juniper / Mountain-mahogany / Elk Sedge, CEGL000724)
- Juniperus occidentalis / Cercocarpus ledifolius / Leymus cinereus Wooded Herbaceous Vegetation (G1Q, CEGL001723)
- Juniperus occidentalis / Cercocarpus ledifolius / Pseudoroegneria spicata Woodland (G4, CEGL000725)
- Juniperus occidentalis / Festuca idahoensis Wooded Herbaceous Vegetation (G2, CEGL001724)
- Juniperus occidentalis / Poa secunda - Achnatherum occidentale Wooded Herbaceous Vegetation (GU, CEGL001727)
- Juniperus occidentalis / Pseudoroegneria spicata Wooded Herbaceous Vegetation (G3, CEGL001728)
- Juniperus occidentalis / Purshia tridentata / Festuca idahoensis - Pseudoroegneria spicata Wooded Herbaceous Vegetation (G3, CEGL002622)
- Pinus ponderosa - Juniperus occidentalis / Artemisia tridentata - Purshia tridentata Woodland (G4, CEGL002688)

- **California community types:**
- Western Juniper Woodland (89.400.00)

SOURCES

References: Barbour and Major 1977, Holland and Keil 1995
Last updated: 20 Feb 2003 **Stakeholders:** WCS
Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.823 ROCKY MOUNTAIN MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND

306, Forest and Woodland

Spatial Scale & Pattern: Matrix **Classification Confidence:** medium
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Montane [Montane], Montane [Lower Montane], Forest and Woodland (Treed), Aridic, Intermediate Disturbance Interval, F-Patch/Medium Intensity, F-Landscape/Medium Intensity, Needle-Leaved Tree, RM Montane Mesic Mixed Conifer, Moderate (100-500 yrs) Persistence

Non-Diagnostic Classifiers: Ridge/Summit/Upper Slope, Side Slope, Temperate, Temperate [Temperate Continental], Mesotrophic Soil, Shallow Soil, Mineral: W/ A Horizon <10 cm

Concept Summary: This is a highly variable ecological system of the montane zone of the Rocky Mountains. It occurs throughout the southern Rockies, north and west into Utah, Nevada, western Wyoming and Idaho. These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Rainfall averages less than 75 cm per year (40 - 60 cm) with summer "monsoons" during the growing season contributing substantial moisture. The composition and structure of overstory is dependent upon the temperature and moisture relationships of the site, and the successional status of the occurrence. *Pseudotsuga menziesii* and *Abies concolor* are most frequent, but *Pinus ponderosa* may be present to codominant. *Pinus flexilis* is common in Nevada. *Pseudotsuga menziesii* forests occupy drier sites, and *Pinus ponderosa* is a common co-dominant. *Abies concolor*-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon side slopes, ridgetops, and north and east-facing slopes which burn somewhat infrequently. *Picea pungens* is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common: *Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambellii* and *Festuca arizonica.* This system was undoubtedly characterized by a mixed severity fire regime in its "natural condition," characterized by a high degree of variability in lethality and return interval.

DISTRIBUTION

Divisions: 304, 306
TNC Ecoregions: 11:C, 18:C, 19:C, 20:C, 21:C, 26:C, 6:C, 68:C, 7:C, 8:C, 9:C
Subnations/Nations: AB:p, AZ:c, BC:p, CO:c, ID:c, MT:c, NV:c, OR:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Abies concolor - Pinus ponderosa / Carex inops ssp. inops Forest (L, G3, CEGL000257)
- Abies concolor - Pinus ponderosa / Cercocarpus ledifolius Forest (G4?, White Fir - Ponerosa Pine - Curl-leaf Mountain-mahogany Forest, CEGL002732)
- Abies concolor - Pinus ponderosa / Symphoricarpos spp. Forest (L, G3, CEGL000018)
- Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest (G4, CEGL000240)
- Abies concolor - Pseudotsuga menziesii / Erigeron eximius Forest (G5, CEGL000247)
- Abies concolor - Pseudotsuga menziesii / Lathyrus lanszwertii var. leucanthus Forest (G3, CEGL000250)
- Abies concolor - Pseudotsuga menziesii / Vaccinium myrtillus Forest (G5, CEGL000265)
- Abies concolor / Arctostaphylos patula Forest (G5, CEGL000242)
- Abies concolor / Arctostaphylos uva-ursi Forest (G5, CEGL000243)
- Abies concolor / Carex siccata Forest (G2, CEGL000244)
- Abies concolor / Cercocarpus ledifolius Woodland (G4, CEGL000885)
- Abies concolor / Festuca arizonica Woodland (G4, CEGL000887)
- Abies concolor / Galium triflorum Woodland (GU, CEGL000888)
- Abies concolor / Juniperus communis Forest (G4?, CEGL000249)
- Abies concolor / Leymus triticoides Woodland (G3, CEGL000886)
- Abies concolor / Mahonia repens Forest (G5, CEGL000251)
- Abies concolor / Muhlenbergia virescens Forest (G5, CEGL000252)
- Abies concolor / Osmorhiza berteroi Forest (G4G5, CEGL000253)
- Abies concolor / Physocarpus malvaceus Forest (G4G5, CEGL000254)
- Abies concolor / Quercus gambelii Forest (G5, CEGL000261)
- Abies concolor / Robinia neomexicana Woodland (G4Q, CEGL000891)
- Abies concolor / Symphoricarpos oreophilus Forest (G5, CEGL000263)
- Picea pungens / Arctostaphylos uva-ursi Forest (G4, CEGL000385)
- Picea pungens / Festuca arizonica Woodland (G5, CEGL000895)
- Pinus ponderosa - Pseudotsuga menziesii / Arctostaphylos nevadensis Woodland (G2, Ponderosa Pine - Douglas-fir / Pinemat Manzanita Woodland, CEGL000208)
- Pinus ponderosa - Pseudotsuga menziesii / Arctostaphylos patula Woodland (G3, CEGL000209)
- Pinus ponderosa - Pseudotsuga menziesii / Calamagrostis rubescens Woodland (G2Q, CEGL000210)
- Pinus ponderosa - Pseudotsuga menziesii / Carex geyeri Forest (G?Q, CEGL000211)
- Pinus ponderosa - Pseudotsuga menziesii / Penstemon fruticosus Woodland (G2G3, CEGL000212)
- Pinus ponderosa - Pseudotsuga menziesii / Physocarpus malvaceus Forest (G?Q, CEGL000213)
- Pinus ponderosa - Pseudotsuga menziesii / Pseudoroegneria spicata ssp. inermis Woodland (G3Q, CEGL000207)
- Pinus ponderosa - Pseudotsuga menziesii / Purshia tridentata Woodland (G3, CEGL000214)
- Pseudotsuga menziesii - Pinus flexilis / Leucopoa kingii Woodland (G4Q, CEGL000906)
- Pseudotsuga menziesii / Amelanchier alnifolia Forest (G2, Douglas-fir / Serviceberry Forest, CEGL000420)
- Pseudotsuga menziesii / Arctostaphylos patula Forest (G4, CEGL000423)
- Pseudotsuga menziesii / Arctostaphylos uva-ursi - Purshia tridentata Forest (G3?, CEGL000426)
- Pseudotsuga menziesii / Arctostaphylos uva-ursi Forest (G4, Douglas-fir / Bearberry Forest, CEGL000424)
- Pseudotsuga menziesii / Arnica cordifolia Forest (G4, Douglas-fir / Heartleaf Arnica Forest, CEGL000427)
- Pseudotsuga menziesii / Bromus ciliatus Forest (G4, CEGL000428)
- Pseudotsuga menziesii / Calamagrostis rubescens Forest (G5, Douglas-fir / Pinegrass Forest, CEGL000429)
- Pseudotsuga menziesii / Carex geyeri Forest (G4?, Douglas-fir / Elk Sedge Forest, CEGL000430)
- Pseudotsuga menziesii / Carex rossii Forest (G2?, CEGL000431)
- Pseudotsuga menziesii / Cercocarpus ledifolius Woodland (G3G4, CEGL000897)
- Pseudotsuga menziesii / Cercocarpus montanus Woodland (G4?, CEGL000898)
- Pseudotsuga menziesii / Festuca arizonica Forest (G5, CEGL000433)
- Pseudotsuga menziesii / Festuca campestris Woodland (G4, Douglas-fir / Rough Fescue Woodland, CEGL000901)
- Pseudotsuga menziesii / Festuca idahoensis Woodland (G4, Douglas-fir / Idaho Fescue Woodland, CEGL000900)

- Pseudotsuga menziesii / Holodiscus dumosus Scree Woodland (G3G4, CEGL000902)
- Pseudotsuga menziesii / Jamesia americana Forest (G3G4, CEGL000438)
- Pseudotsuga menziesii / Juniperus communis Forest (G4, Douglas-fir / Common Juniper Forest, CEGL000439)
- Pseudotsuga menziesii / Juniperus osteosperma Forest (G2?, CEGL000440)
- Pseudotsuga menziesii / Juniperus scopulorum Woodland (G3, Douglas-fir / Rocky Mountain Juniper Woodland, CEGL000903)
- Pseudotsuga menziesii / Leucopoa kingii Woodland (G3G4, CEGL000904)
- Pseudotsuga menziesii / Linnaea borealis Forest (G4, Douglas-fir / Twinflower Forest, CEGL000441)
- Pseudotsuga menziesii / Mahonia repens Forest (G5, Douglas-fir / Oregon-grape Forest, CEGL000442)
- Pseudotsuga menziesii / Muhlenbergia montana Forest (G4, CEGL000443)
- Pseudotsuga menziesii / Muhlenbergia virescens Forest (G4, CEGL000444)
- Pseudotsuga menziesii / Osmorhiza berteroi Forest (G4G5, CEGL000445)
- Pseudotsuga menziesii / Paxistima myrsinites Forest (G2G3, CEGL000446)
- Pseudotsuga menziesii / Physocarpus malvaceus - Linnaea borealis Forest (G4, CEGL000448)
- Pseudotsuga menziesii / Physocarpus malvaceus Forest (G5, CEGL000447)
- Pseudotsuga menziesii / Physocarpus monogynus Forest (G4, CEGL000449)
- Pseudotsuga menziesii / Pseudoroegneria spicata Woodland (G4, Douglas-fir / Bluebunch Wheatgrass Woodland, CEGL000908)
- Pseudotsuga menziesii / Purshia tridentata Woodland (G3Q, CEGL000909)
- Pseudotsuga menziesii / Quercus arizonica Forest (G3?, CEGL000451)
- Pseudotsuga menziesii / Quercus gambelii Forest (G5, CEGL000452)
- Pseudotsuga menziesii / Quercus hypoleucoides Forest (G3, CEGL000453)
- Pseudotsuga menziesii / Quercus rugosa Forest (G2, Douglas-fir / Netleaf Oak, CEGL000454)
- Pseudotsuga menziesii / Quercus X pauciloba Forest (GU, CEGL000455)
- Pseudotsuga menziesii / Spiraea betulifolia Forest (G5, Douglas-fir / Shiny-leaf Spiraea Forest, CEGL000457)
- Pseudotsuga menziesii / Symphoricarpos albus Forest (G5, Douglas-fir / Snowberry Forest, CEGL000459)
- Pseudotsuga menziesii / Symphoricarpos occidentalis Forest (G3?, Douglas-fir / Wolfberry Forest, CEGL000461)
- Pseudotsuga menziesii / Symphoricarpos oreophilus Forest (G5, CEGL000462)
- Pseudotsuga menziesii / Vaccinium caespitosum Forest (G5, Douglas-fir / Dwarf Huckleberry Forest, CEGL000465)
- Pseudotsuga menziesii / Vaccinium spp. Forest (G4Q, CEGL000464)

Vegetation: This highly variable ecological system is comprised of mixed conifer forests at montane elevations throughout the Inter-mountain region. The four main alliances in this system are found on slightly different, but intermingled, biophysical environments: *Abies concolor* dominates at higher, colder locations; *Picea pungens* represents mesic conditions; *Pseudotsuga menziesii* dominates intermediate zones. As many as seven conifers can be found growing in the same occurrences, with the successful reproduction of the diagnostic species determining the association type. Common conifers include *Pinus ponderosa, Pinus flexilis, Abies lasiocarpa* var. *lasiocarpa*, *A. lasiocarpa* var. *arizonica, Juniperus scopulorum, Picea engelmannii*. *Populus tremuloides* is often present as intermingled individuals in remnant aspen clones, or in adjacent patches. The composition and structure of overstory is dependent upon the temperature and moisture relationships of the site, and the successional status of the occurrence (DeVelice *et al.* 1986, Muldavin *et al.* 1996).

A number of cold-deciduous shrub and graminoid species are found in many occurrences (*e.g., Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambelii* and *Festuca arizonica*). Other important species include: *Acer glabrum, A. grandidentatum, Amelanchier alnifolia, Arctostaphylos patula, Holodiscus dumosus, Jamesia americana, Juniperus communis, Physocarpus monogynus, Quercus arizonica, Q. rugosa, Q. pauciloba*, *Q. hypoleucoides, Robinia neomexicana, Rubus parviflorus and Vaccinium myrtillus*. Where soil moisture is favorable, the herbaceous layer may be quite diverse, including graminoids *Bromus ciliatus, B. canadensis, Calamagrostis rubescens, Carex geyeri, C. rossii, C. foenea, Festuca occidentalis, Koeleria macrantha, Muhlenbergia montana*, *M. virescens*, *Poa fendleriana, Pseudoroegneria spicata,* and forbs: *Achillea millefolium*. *Arnica cordifolia, Erigeron eximius*, *Fragaria virginiana, Linnaea borealis, Luzula parviflora, , Osmorhiza berteroi, Senecio cardamine, Thalictrum occidentale, T. fendleri,, Thermopsis*

rhombifolia, Viola adunca, and species of many other genera, including *Lathyrus, Penstemon, Lupinus, Vicia, Arenaria, Galium*, and others.

Dynamics: Forests in this ecological system represent the gamut of fire tolerance. Formerly, *Abies concolor* in the Utah High Plateaus were restricted to rather moist or less fire prone areas by frequent ground fires. These areas experienced mixed fire severities, with patches of crowning in which all trees are killed, intermingled with patches of underburn in which larger *A. concolor* survived (www.fs.fed.us/database/feis/). With fire suppression, *Abies concolor* has vigorously colonized many sites formerly occupied by open *Pinus ponderosa* woodlands. These invasions have dramatically changed the fuel load and potential behavior of fire in these forests. In particular, the potential for high intensity crownfires on drier sites now codominated by *P. ponderosa* and *A. concolor* has increased. Increased landscape connectivity, in terms of fuel loadings and crown closure, has also increased the potential size of crown fires.

Pseudotsuga menziesii forests are the only true 'fire tolerant' occurrences in this ecological system. *P. menziesii* forests were probably subject to a moderate severity fire regime in pre-settlement times, with fire return intervals of 30-100 years. Many of the important tree species in these forests are fire-adapted (*Populus tremuloides, Pinus ponderosa, Pinus contorta*) (Pfister *et al.* 1977), and fire-induced reproduction of *Pinus ponderosa* can result in its continued codominance in *P. menziesii* forests (Steele *et al.* 1981). Seeds of the shrub *Ceanothus velutinus* can remain dormant in forest occurrences of 200 years (Steele *et al.* 1981) and germinate abundantly after fire, competitively suppressing conifer seedlings. Successional relationships in this system are complex. *Pseudotsuga menziesii* is less shade-tolerant than many northern or montane trees such as *Tsuga heterophylla, Abies concolor, Picea engelmannii*, and seedlings compete poorly in deep shade. At drier locales, seedlings may be favored by moderate shading, such as by a canopy of *Pinus ponderosa*, which helps to minimize drought stress. In some locations, much of these forests have been logged or burned during European settlement, and present-day occurrences are second-growth forests dating from fire, logging, or other occurrence replacing disturbances (Mauk and Henderson 1984, Chappell *et al.* 1997).

Picea pungens is a slow-growing, long-lived tree which regenerates from seed (Burns and Honkala 1990). Seedlings are shallow rooted and require perennially moist soils for establishment and optimal growth. *P. pungens* is intermediate in shade tolerance, being somewhat more tolerant than *Pinus ponderosa* or *Pseudotsuga menziesii*, and less tolerant than *Abies lasiocarpa* or *Picea engelmannii*. It forms late seral occurrences in the subhumid regions of the Utah High Plateaus. It is common for these forests to be heavily disturbed by grazing or fire.

In general, fire suppression has lead to the encroachment of more shade-tolerant, less fire-tolerant species (*e.g.,* climax) into occurrences and an attendant increase in landscape homogeneity and connectivity (from a fuels perspective). This has increased the lethality and potential size of fires.

SOURCES

References: Alexander et al. 1984b, Alexander et al. 1987, Boyce 1977, Bunin 1975c, CanRock 2002, Comer et al. 2002, Cooper et al. 1991, DeVelice et al. 1986, Fitzhugh et al. 1987, Giese 1975, Heinze et al. 1962, Hess 1981, Hess and Alexander 1986, Hess and Wasser 1982, Hoffman and Alexander 1980, Hoffman and Alexander 1983, Komarkova et al. 1988b, Mauk and Henderson 1984, Nachlinger et al. 2001, Neely et al. 2001, Pfister 1972, Tuhy et al. 2002, Youngblood and Mauk 1985

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.825 ROCKY MOUNTAIN MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND

306, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Forest and Woodland (Treed), Ravine, Stream terrace (undifferentiated), Toeslope, Mesotrophic Soil, Ustic, Long Disturbance Interval, F-Patch/Low Intensity, F-Landscape/Low Intensity, Needle-Leaved Tree, RM Montane Dry-mesic Mixed Conifer

Non-Diagnostic Classifiers: Montane [Montane], Montane [Lower Montane], Temperate, Temperate [Temperate Continental], Shallow Soil, Mineral: W/ A Horizon <10 cm, Moderate (100-500 yrs) Persistence

Concept Summary: These are mixed conifer forests of the Rocky Mountains west into the ranges of the Great Basin, occurring predominantly in cool ravines and on north-facing slopes. Elevations range from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than the Rocky Mountain Montane Dry-Mesic

Mixed Conifer Forest and Woodland. Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north and east-facing slopes which burn somewhat infrequently. *Pseudotsuga menziesii* and *Abies concolor* are most common canopy dominants, but *Picea engelmannii*, *P. pungens*, or *Pinus ponderosa* may be present. This system includes mixed conifer/*Populus tremuloides* stands. A number of cold-deciduous shrub species can occur, including *Acer glabrum*, *A. grandidentatum*, *Alnus incana*, *Betula occidentalis*, *Cornus sericea*, *Jamesia americana*, *Physocarpus malvaceus*, *Robinia neomexicana*, *Vaccinium membranaceum*, and *V. myrtillus*. Herbaceous species include *Bromus ciliatus*, *Carex geyeri*, *C. rossii*, *C. siccata*, *Muhlenbergia virescens*, *Pseudoroegneria spicata*, *Erigeron eximius*, *Fragaria virginiana*, *Luzula parviflora*, *Osmorhiza berteroi*, *Packera cardamine*, *Thalictrum occidentale*, and *T. fendleri*. Naturally occurring fires are of variable return intervals, and mostly light, erratic, and infrequent due to the cool, moist conditions.

Comments: This system will need to be modeled to separate from similar dry-mesic system.

DISTRIBUTION

Divisions: 304, 306
TNC Ecoregions: 11:C, 18:C, 19:C, 20:C, 21:C, 68:P, 7:C, 8:C, 9:C
Subnations/Nations: AB:p, AZ:c, BC:p, CO:c, ID:c, MT:c, NM:c, NV:c, OR:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Abies concolor - Picea pungens - Populus angustifolia / Acer glabrum Forest (G2, White Fir - Colorado Blue Spruce - Narrowleaf Cottonwood / Rocky Mountain Maple, CEGL000255)
- Abies concolor - Pinus ponderosa / Cercocarpus ledifolius Forest (G4?, White Fir - Ponerosa Pine - Curl-leaf Mountain-mahogany Forest, CEGL002732)
- Abies concolor - Pseudotsuga menziesii / Acer glabrum Forest (G4, CEGL000240)
- Abies concolor - Pseudotsuga menziesii / Erigeron eximius Forest (G5, CEGL000247)
- Abies concolor - Pseudotsuga menziesii / Lathyrus lanszwertii var. leucanthus Forest (G3, CEGL000250)
- Abies concolor - Pseudotsuga menziesii / Vaccinium myrtillus Forest (G5, CEGL000265)
- Abies concolor / Acer grandidentatum Forest (G4, CEGL000241)
- Abies concolor / Arctostaphylos patula Forest (G5, CEGL000242)
- Abies concolor / Arctostaphylos uva-ursi Forest (G5, CEGL000243)
- Abies concolor / Carex siccata Forest (G2, CEGL000244)
- Abies concolor / Festuca arizonica Woodland (G4, CEGL000887)
- Abies concolor / Galium triflorum Woodland (GU, CEGL000888)
- Abies concolor / Holodiscus dumosus Scree Woodland (G4, CEGL000889)
- Abies concolor / Jamesia americana Scree Woodland (L, G?, CEGL000890)
- Abies concolor / Juglans major Forest (G2G3, CEGL000248)
- Abies concolor / Leymus triticoides Woodland (G3, CEGL000886)
- Abies concolor / Mahonia repens Forest (G5, CEGL000251)
- Abies concolor / Muhlenbergia virescens Forest (G5, CEGL000252)
- Abies concolor / Osmorhiza berteroi Forest (G4G5, CEGL000253)
- Abies concolor / Physocarpus malvaceus Forest (G4G5, CEGL000254)
- Abies concolor / Quercus gambelii Forest (G5, CEGL000261)
- Abies concolor / Robinia neomexicana Woodland (G4Q, CEGL000891)
- Abies concolor / Symphoricarpos oreophilus Forest (G5, CEGL000263)
- Picea pungens / Alnus incana Woodland (L, G3, Colorado Blue Spruce / Thinleaf Alder, CEGL000894)
- Picea pungens / Arctostaphylos uva-ursi Forest (G4, CEGL000385)
- Picea pungens / Arnica cordifolia Forest (G3?, CEGL000386)
- Picea pungens / Betula occidentalis Woodland (L, G2, CEGL002637)
- Picea pungens / Carex siccata Forest (G4, CEGL000387)
- Picea pungens / Cornus sericea Woodland (L, G4, CEGL000388)
- Picea pungens / Dasiphora fruticosa ssp. floribunda Woodland (L, G2G3, Blue Spruce / Shrubby-cinquefoil Woodland, CEGL000396)
- Picea pungens / Equisetum arvense Woodland (L, G3?, CEGL000389)
- Picea pungens / Erigeron eximius Forest (G5, Blue Spruce / Forest Fleabane Forest, CEGL000390)
- Picea pungens / Festuca arizonica Woodland (G5, CEGL000895)
- Picea pungens / Fragaria virginiana ssp. virginiana Forest (G3G4, CEGL000391)

- Picea pungens / Juniperus communis Forest (G4G5, CEGL000392)
- Picea pungens / Linnaea borealis Forest (G4, CEGL000393)
- Picea pungens / Lonicera involucrata Forest (G2, Colorado Blue Spruce / Black Twinberry, CEGL000394)
- Picea pungens / Mahonia repens Forest (G5, CEGL000395)
- Picea pungens / Packera cardamine Forest (GU, CEGL000399)
- Picea pungens / Pseudoroegneria spicata Forest (G4?, CEGL000397)
- Picea pungens / Rosa woodsii Woodland (G?, CEGL000398)
- Pseudotsuga menziesii / Acer glabrum Forest (G4?, CEGL000418)
- Pseudotsuga menziesii / Acer grandidentatum Forest (G?, CEGL000419)
- Pseudotsuga menziesii / Betula occidentalis Woodland (G3?, CEGL002639)
- Pseudotsuga menziesii / Bromus ciliatus Forest (G4, CEGL000428)
- Pseudotsuga menziesii / Cornus sericea Woodland (G4, Douglas-fir / Red-osier Dogwood Woodland, CEGL000899)
- Pseudotsuga menziesii / Vaccinium membranaceum Forest (G5?, CEGL000466)
- Pseudotsuga menziesii / Viola adunca var. adunca Forest (G3, Douglas-fir / Canada Violet Forest, CEGL000467)

SOURCES

References: Alexander et al. 1984b, Alexander et al. 1987, Boyce 1977, Bunin 1975c, Comer et al. 2002, Cooper et al. 1991, DeVelice et al. 1986, Fitzhugh et al. 1987, Giese 1975, Heinze et al. 1962, Hess 1981, Hess and Alexander 1986, Hess and Wasser 1982, Hoffman and Alexander 1980, Hoffman and Alexander 1983, Komarkova et al. 1988b, Mauk and Henderson 1984, Nachlinger et al. 2001, Neely et al. 2001, Pfister 1972, Tuhy et al. 2002, Youngblood and Mauk 1985

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.805 NORTHERN ROCKY MOUNTAIN MONTANE MIXED CONIFER FOREST

306, Forest and Woodland

Spatial Scale & Pattern: Matrix **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Montane [Montane], Forest and Woodland (Treed), Ustic, Short Disturbance Interval, F-Patch/Low Intensity, Needle-Leaved Tree, Abies grandis-mixed

Non-Diagnostic Classifiers: Montane [Lower Montane], Side Slope, Toeslope/Valley Bottom, Temperate [Temperate Continental], Mesotrophic Soil, Moderate (100-500 yrs) Persistence

Concept Summary: This ecological system is composed of highly variable montane coniferous forests found in the interior Pacific Northwest, from southern interior British Columbia south and east into Oregon, Idaho, and western Montana. This system is associated with a submesic climate regime with annual precipitation ranging from 50 to 100 cm, with a maximum in winter or late-spring. Winter snow packs typically melt off in early spring at lower elevation sites. Elevations range from 460 to 1920 m. Most occurrences of this system are dominated by a mix of *Pseudotsuga menziesii* and *Pinus ponderosa*, with lesser amounts of *Abies grandis*. Other typically seral species include *Pinus contorta*, *P monticola*, and *Larix occidentalis*. *Picea engelmannii* and *Taxus brevifolia* become increasingly common towards the eastern edge of the range; *Tsuga heterophylla* and *Thuja plicata* may be associates on moister sites. *Abies grandis* (a fire sensitive, shade tolerant species) forests include many sites once dominated by *Pseudotsuga menziesii* and *Pinus ponderosa*, which were formerly maintained by wildfire. Pre-settlement fire regimes were characterized by frequent, low-intensity ground fires that maintained relatively open stands of a mix of fire-resistant species. With vigorous fire suppression, longer fire-return intervals are now the rule, and multi-layered stands of *Abies grandis* which provide fuel "ladders", making these forests more susceptible to high intensity, stand-replacing fires. This system also includes montane forests along rivers and slopes, and in mesic "coves" which were historically protected from wildfires. They are very productive forests which have been priorities for timber production.

DISTRIBUTION

Divisions: 204, 304, 306

TNC Ecoregions: 2:P, 4:C, 6:C, 68:C, 7:C, 8:C

Subnations/Nations: BC:c, ID:c, MT:c, OR:c, WA:c

CONCEPT

Associations:

- Abies grandis / Acer circinatum Forest (G4, CEGL000266)
- Abies grandis / Acer glabrum Forest (G3, CEGL000267)
- Abies grandis / Asarum caudatum Forest (G4, CEGL000269)
- Abies grandis / Bromus vulgaris Forest (G3, CEGL002601)
- Abies grandis / Calamagrostis rubescens Woodland (G4?, CEGL000916)
- Abies grandis / Carex geyeri Woodland (G3, CEGL000917)
- Abies grandis / Clintonia uniflora Forest (G5, CEGL000272)
- Abies grandis / Coptis occidentalis Forest (G2, Grand Fir / Western Goldthread, CEGL000273)
- Abies grandis / Linnaea borealis Forest (G3, CEGL000275)
- Abies grandis / Physocarpus malvaceus Forest (G3, CEGL000277)
- Abies grandis / Spiraea betulifolia Forest (G2, CEGL000281)
- Abies grandis / Symphoricarpos albus Forest (G3?, CEGL000282)
- Abies grandis / Taxus brevifolia Forest (G2, Grand Fir / Pacific Yew Forest, CEGL000283)
- Abies grandis / Trautvetteria caroliniensis Forest (G3, CEGL000285)
- Abies grandis / Vaccinium caespitosum Forest (G2, Grand Fir / Dwarf Huckleberry, CEGL000288)
- Abies grandis / Vaccinium membranaceum Forest (G3G4, CEGL000290)
- Abies grandis / Vaccinium membranaceum Rocky Mountain Forest (G3, CEGL000289)
- Abies grandis / Vaccinium scoparium Forest (G4, CEGL000292)
- Abies grandis / Xerophyllum tenax Forest (G4, CEGL000293)
- Larix occidentalis Forest [Placeholder] (G4Q, CEGL000624)
- Pinus monticola / Clintonia uniflora Forest (G1Q, CEGL000176)
- Thuja plicata / Adiantum pedatum Forest (G2?, Western Red-cedar / Maidenhair Fern, CEGL000470)
- Thuja plicata / Asarum caudatum Forest (G5, CEGL000472)
- Thuja plicata / Clintonia uniflora Forest (G4, CEGL000474)
- Thuja plicata / Gymnocarpium dryopteris Forest (G3, CEGL000476)

SOURCES

References: CanRock 2002, Cooper et al. 1987, Crawford and Johnson 1985, Daubenmire and Daubenmire 1968, Lillybridge et al. 1995, Pfister et al. 1977, Steele and Geier-Hayes 1995, Steele et al. 1981, Topik 1989, Topik et al. 1988, Williams and Lillybridge 1983

Last updated: 20 Feb 2003 **Stakeholders:** WCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.804 NORTHERN ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND

306, Woody Wetland

Spatial Scale & Pattern: Linear **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland

Diagnostic Classifiers: Montane [Lower Montane], Riverine / Alluvial, Short (<5 yrs) Flooding Interval [Short interval, Spring Flooding]

Non-Diagnostic Classifiers: Montane, Forest and Woodland (Treed), Shrubland (Shrub-dominated), Temperate, Temperate [Temperate Continental], Unconsolidated, Circumneutral Water

Concept Summary: This system of the northern Rocky Mountains consists of deciduous, and mixed conifer and deciduous forests that occur on stream banks and river floodplains of the lower montane into foothill zones. Riparian forest stands are maintained by annual flooding and hydric soils throughout the growing season. Riparian forests are often accompanied by riparian shrublands or open areas dominated by wet meadows. *Populus balsamifera* is the key indicator species. Several other tree species can be mixed in the canopy, *Populus tremuloides, Betula papyrifera, B. occidentalis, Picea mariana*, and *Picea glauca.* Shrub understory components include *Cornus sericea, Alnus incana, Betula papyrifera*, and *Symphoricarpos albus.*

Comments: this is from the Canadian Rockies ecoregion project, & represents lower montane riparian in montana north into CA. Valid to split from the other RM riparian things, or are they the same?

DISTRIBUTION

Divisions: 303, 306
TNC Ecoregions: 68:C, 7:C, 8:C
Subnations/Nations: AB:c, BC:c, ID:c, MT:c, OR:p, WA:c

CONCEPT

Associations:
- Betula papyrifera Forest [Placeholder] (G4Q, CEGL000520)
- Populus balsamifera ssp. trichocarpa / Alnus incana Forest (G3, CEGL000667)
- Populus balsamifera ssp. trichocarpa / Betula papyrifera Forest (G?Q, CEGL000670)
- Populus balsamifera ssp. trichocarpa / Cornus sericea Forest (G3?, CEGL000672)
- Populus balsamifera ssp. trichocarpa / Oplopanax horridus - Acer glabrum Forest (G2, CEGL000482)
- Populus balsamifera ssp. trichocarpa / Symphoricarpos albus Forest (G2, CEGL000677)
- Populus tremuloides - Populus balsamifera ssp. trichocarpa / Osmorhiza occidentalis Forest (G2Q, Quaking Aspen - Black Cottonwood / Sierran Sweet-cicely, CEGL000542)

SOURCES

References: CanRock 2002, Hansen et al. 1988b, Hansen et al. 1989
Last updated: 20 Feb 2003 **Stakeholders:** WCS, CAN
Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.821 ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND

306, Woody Wetland

Spatial Scale & Pattern: Linear **Classification Confidence:** medium
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland
Diagnostic Classifiers: Montane [Lower Montane], Mineral: W/ A Horizon <10 cm, Unconsolidated, Short (50-100 yrs) Persistence, Riverine / Alluvial, Short (<5 yrs) Flooding Interval

Non-Diagnostic Classifiers: Montane, Forest and Woodland (Treed), Shrubland (Shrub-dominated), Braided channel or stream, Drainage bottom (undifferentiated), Floodplain, Stream terrace (undifferentiated), Valley bottom, Temperate, Temperate [Temperate Continental], Circumneutral Water

Concept Summary: This system is found throughout the region within a broad elevation range from approximately 900 to 2,800 m. This system often occurs as a mosaic of multiple communities that are tree dominated with a diverse shrub component. This system is dependent on a natural hydrologic regime especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate stream banks. They can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennial wet, but less scoured sites, such as floodplains swales and irrigation ditches. Dominant trees may include *Acer negundo, Populus angustifolia, P. balsamifera, P. deltoides, P. fremontii, Pseudotsuaga menziesii, Picea pungens, Salix amygadaloides,* or *Juniperus scopulorum.* Dominant shrubs include *Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, S. drummondiana, S. exigua, S. irrorata, S. lucida, Shepherdia argentea,* or *Symphoricarpos* spp. Exotic trees of *Elaeagus angustifolia* and *Tamarix* spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests.

DISTRIBUTION

Divisions: 304, 306
TNC Ecoregions: 11:C, 18:C, 19:C, 20:C, 21:C, 25:C, 6:P, 8:C, 9:C
Subnations/Nations: AZ:c, CO:c, ID:c, MT:c, NM:c, NV:c, OR:c, SD:c, UT:c, WY:c

CONCEPT

Associations:
- Acer negundo - Populus angustifolia / Cornus sericea Forest (G2, Box-elder - Narrowleaf Cottonwood / Red-osier Dogwood, CEGL000627)
- Acer negundo / Betula occidentalis Woodland (G1G2, CEGL000936)
- Acer negundo / Brickellia grandiflora Woodland [Provisional] (G?, CEGL002692)
- Acer negundo / Cornus sericea Forest (G3?, CEGL000625)

- Acer negundo / Disturbed Understory Woodland [Provisional] (G?, CEGL002693)
- Acer negundo / Equisetum arvense Forest (G2?, CEGL000626)
- Acer negundo / Prunus virginiana Forest (G3, Box-elder / Choke Cherry Forest, CEGL000628)
- Betula occidentalis / Purshia tridentata / Hesperostipa comata Shrubland (G1, River Birch - Bitterbrush / Needle-and-Thread, CEGL001084)
- Betula papyrifera / Corylus cornuta Forest (G2G3, Paper Birch / Hazel Forest, CEGL002079)
- Equisetum (arvense, variegatum) Herbaceous Vegetation (G?, Horsetail Marsh, CEGL005148)
- Forestiera pubescens Shrubland (G1G2, Wild-privet Shrubland, CEGL001168)
- Fraxinus anomala Woodland (GUQ, Anomalous Ash Woodland, CEGL002752)
- Juniperus scopulorum / Cornus sericea Woodland (G4, Rocky Mountain Juniper / Red-osier Dogwood Woodland, CEGL000746)
- Juniperus scopulorum Temporarily Flooded Woodland [Placeholder] (G1, Rocky Mountain Juniper Temporarily Flooded Woodland, CEGL002777)
- Juniperus scopulorum Woodland (G?, Texas Rocky Mountain Juniper Woodland, CEGL003550)
- Pinus ponderosa / Alnus incana Woodland (G2, CEGL002638)
- Pinus ponderosa / Cornus sericea Woodland (G3, Ponderosa Pine / Red-osier Dogwood Wetland Woodland, CEGL000853)
- Pinus ponderosa / Crataegus douglasii Woodland (G1, Ponderosa Pine / Douglas Hawthorn Woodland, CEGL000855)
- Pinus ponderosa / Juglans major Woodland (G2, CEGL000858)
- Pinus ponderosa Temporarily Flooded Woodland [Placeholder] (G3, Ponderosa Pine Riparian Woodland, CEGL002766)
- Poa pratensis Semi-natural Seasonally Flooded Herbaceous Vegetation [Placeholder] (GW, CEGL003081)
- Populus angustifolia - Juniperus scopulorum Woodland (G2G3, CEGL002640)
- Populus angustifolia - Picea pungens / Alnus incana Woodland (G3, Narrowleaf Cottonwood - Colorado Blue Spruce / Thinleaf Alder, CEGL000934)
- Populus angustifolia - Pinus ponderosa Woodland (G4Q, CEGL000935)
- Populus angustifolia - Populus deltoides - Salix amygdaloides Forest (GUQ, CEGL000656)
- Populus angustifolia - Pseudotsuga menziesii Woodland (G3, CEGL002641)
- Populus angustifolia / Acer grandidentatum Forest (G2G3, CEGL000646)
- Populus angustifolia / Alnus incana Woodland (G3, CEGL002642)
- Populus angustifolia / Betula occidentalis Woodland (G3, CEGL000648)
- Populus angustifolia / Cornus sericea Woodland (G4, Narrowleaf Cottonwood / Red-osier Dogwood Forest, CEGL002664)
- Populus angustifolia / Crataegus rivularis Woodland (G2?, CEGL002644)
- Populus angustifolia / Lonicera involucrata Forest (GUQ, CEGL000650)
- Populus angustifolia / Prunus virginiana Woodland (G2Q, CEGL000651)
- Populus angustifolia / Rhus trilobata Woodland (G3, CEGL000652)
- Populus angustifolia / Salix (monticola, drummondiana, lucida) Woodland (G3, CEGL002645)
- Populus angustifolia / Salix drummondiana - Acer glabrum Woodland (G2?, CEGL002646)
- Populus angustifolia / Salix exigua Woodland (G4, CEGL000654)
- Populus angustifolia / Salix irrorata Woodland (G2, CEGL002647)
- Populus angustifolia / Salix ligulifolia - Shepherdia argentea Woodland (G1, CEGL000655)
- Populus angustifolia / Symphoricarpos albus Woodland (G2Q, CEGL002648)
- Populus angustifolia Sand Dune Forest (G1, CEGL002643)
- Populus deltoides - (Salix amygdaloides) / Salix (exigua, interior) Woodland (G3G4, Cottonwood - Peachleaf Willow Floodplain Woodland, CEGL000659)
- Populus deltoides / Symphoricarpos occidentalis Woodland (G2G3, Cottonwood / Western Snowberry Woodland, CEGL000660)
- Populus deltoides ssp. wislizeni / Rhus trilobata Woodland (G2, Rio Grande Cottonwood / Skunkbrush, CEGL000940)
- Populus fremontii / Betula occidentalis Wooded Shrubland (G?, CEGL002981)
- Populus fremontii / Leymus triticoides Woodland (G?, Fremont Cottonwood / Alkali Wild Rye Woodland, CEGL002756)
- Populus fremontii / Salix exigua Forest (G?, Fremont Cottonwood / Sandbar Willow Forest, CEGL000666)
- Populus fremontii / Salix geyeriana Woodland (G3?, CEGL000943)

- Pseudotsuga menziesii / Betula occidentalis Woodland (G3?, CEGL002639)
- Pseudotsuga menziesii / Cornus sericea Woodland (G4, Douglas-fir / Red-osier Dogwood Woodland, CEGL000899)
- Rhus trilobata Intermittently Flooded Shrubland (G3, CEGL001121)
- Salix amygdaloides Woodland (G3, Peachleaf Willow Woodland, CEGL000947)
- Salix eastwoodiae / Carex aquatilis Shrubland (G2, CEGL001195)
- Salix eastwoodiae / Carex utriculata Shrubland (G2?, CEGL001196)
- Salix eastwoodiae Shrubland [Placeholder] (G2Q, CEGL001194)
- Salix exigua - Salix ligulifolia Shrubland (G2G3, CEGL002655)
- Salix exigua - Salix lucida ssp. caudata Shrubland (G2, CEGL001204)
- Salix exigua / Agrostis stolonifera Shrubland (GM, Sandbar Willow / Redtop Shrubland, CEGL001199)
- Salix exigua / Barren Shrubland (G5, CEGL001200)
- Salix exigua / Elymus X pseudorepens Shrubland (G3, Sandbar Willow / Quackgrass Shrubland, CEGL001198)
- Salix exigua / Equisetum arvense Shrubland (G3, Sandbar Willow / Common Horsetail Shrubland, CEGL001201)
- Salix exigua / Mesic Forbs Shrubland (G2, CEGL001202)
- Salix exigua / Mesic Graminoids Shrubland (G5, Sandbar Willow / Mesic Graminoids Shrubland, CEGL001203)
- Salix exigua Temporarily Flooded Shrubland (G5, Sandbar Willow Shrubland, CEGL001197)
- Salix irrorata Shrubland (G?, New Mexico Sandbar Willow Shrubland, CEGL001214)
- Salix lasiolepis - Cornus sericea / Rosa woodsii Shrubland (G2G3, CEGL003453)
- Salix lasiolepis / Barren Ground Shrubland (G3?, CEGL001216)
- Salix lasiolepis / Rosa woodsii / Mixed Herbs Shrubland (G3Q, CEGL001217)
- Shepherdia argentea Shrubland (G3G4, Buffaloberry Shrubland, CEGL001128)

Environment: This system is dependent on a natural hydrologic regime especially annual to episodic flooding. This ecological system is found within the flood zone of rivers, on islands, sand or cobble bars, and immediate stream banks. It can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennial wet, but less scoured sites, such as floodplains swales and irrigation ditches. It may also occur in upland areas of mesic swales and hillslopes below seeps and springs.

The climate of this system is continental with typically cold winters and hot summers.

Surface water is generally high for variable periods. Soils are typically alluvial deposits of sand, clays, silts and cobbles that are highly stratified with depth due to flood scour and deposition. Highly stratified profiles consist of alternating layers of clay loam and organic material with coarser sand or thin layers of sandy loam over very coarse alluvium. Soils are fine textured with organic material over coarser alluvium. Some soils are more developed due to a slightly more stable environment and greater input of organic matter.

Dynamics: This ecological system contains early seral, mid- and late seral riparian plant associations. It also contains non-obligate riparian species. Cottonwood communities are early, mid- or late seral, depending on the age class of the trees and the associated species of the occurrence (Kittel et al. 1998). Cottonwoods, however, do not reach a climax stage as defined by Daubenmire (1952). Mature cottonwood occurrences do not regenerate in place, but regenerate by "moving" up and down a river reach. Over time a healthy riparian area supports all stages of cottonwood communities (Kittel et al. 1999b).

SOURCES

References: Baker 1988, Baker 1989a, Baker 1989b, Baker 1990, Comer et al. 2002, Crowe and Clausnitzer 1997, Kittel et al. 1999b, Kovalchik 1987, Kovalchik 1992, Manning and Padgett 1995, Muldavin et al. 2000a, Nachlinger et al. 2001, Neely et al. 2001, Padgett et al. 1989, Szaro 1989, Tuhy et al. 2002, Walford 1996, Walford et al. 1997, Walford et al. 2001

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.832 ROCKY MOUNTAIN SUBALPINE-MONTANE RIPARIAN SHRUBLAND

306, Woody Wetland

Spatial Scale & Pattern: Linear **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Wetland

Diagnostic Classifiers: Montane [Upper Montane], Montane [Montane], Shrubland (Shrub-dominated), Broad-Leaved Deciduous Shrub, RM Subalpine/Montane Riparian Woodland, Short (50-100 yrs) Persistence, Riverine / Alluvial, Short (<5 yrs) Flooding Interval

Non-Diagnostic Classifiers: Montane [Lower Montane], Alluvial terrace, Drainage bottom (undifferentiated), Erosional stream terrace, Floodplain, Stream terrace (undifferentiated), Valley bottom, Temperate, Temperate [Temperate Continental], Mineral: W/ A Horizon <10 cm, Circumneutral Water

Concept Summary: This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana, and also occurs in mountainous ares of the Inter-mountain region and Colorado Plateau. These are montane to subalpine riparian shrublands occurring as narrow bands of shrubs lining stream banks and alluvial terraces in narrow to wide, low gradient valley bottoms and flood plains with sinuous stream channels. Generally it is found at higher elevations, but can be found anywhere from 1700 - 3475 m. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley bottoms. Many of the plant associations found within this system are associated with beaver activity. This system often occurs as a mosaic of multiple communities that are shrub and herb dominated and includes above treeline, willow dominated, snow-melt fed basins that feed into streams. The dominant shrubs reflect the large elevational gradient and include *Alnus incana, Betula nana, B. occidentalis, Cornus sericea, Salix bebbiana, S. boothii, S. brachycarpa, S. drummondiana, S. eriocephala, S. geyeriana, S. moniticola, S. planifolia,* and *S. wolfii.* Generally the upland vegetation surrounding these riparian systems are of either conifer or aspen forests.

DISTRIBUTION

Divisions: 304, 306
TNC Ecoregions: 11:C, 18:C, 19:C, 20:C, 21:C, 25:C, 6:P, 68:C, 7:C, 8:C, 9:C
Subnations/Nations: AB:c, AZ:c, BC:c, CO:c, ID:c, MT:c, NM:c, NV:c, OR:c, SD:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Acer glabrum Drainage Bottom Shrubland (G4?, Rocky Mountain Maple Drainage Bottom Shrubland, CEGL001062)
- Alnus incana - Betula occidentalis Shrubland (G2G3, CEGL001142)
- Alnus incana - Salix (monticola, lucida, ligulifolia) Shrubland (G3, CEGL002651)
- Alnus incana - Salix drummondiana Shrubland (G3, CEGL002652)
- Alnus incana / Athyrium filix-femina Shrubland (G3, CEGL002628)
- Alnus incana / Calamagrostis canadensis Shrubland (G3Q, Mountain Alder / Bluejoint Shrubland, CEGL001143)
- Alnus incana / Carex (aquatilis, deweyana, lenticularis, luzulina, pellita) Shrubland (G3, CEGL001144)
- Alnus incana / Carex scopulorum var. prionophylla Shrubland (G1, CEGL000122)
- Alnus incana / Cornus sericea Shrubland (G3Q, CEGL001145)
- Alnus incana / Equisetum arvense Shrubland (G3, CEGL001146)
- Alnus incana / Glyceria striata Shrubland (G3, CEGL000228)
- Alnus incana / Lysichiton americanus Shrubland (G3, CEGL002629)
- Alnus incana / Mesic Forbs Shrubland (G3, CEGL001147)
- Alnus incana / Mesic Graminoids Shrubland (G3, CEGL001148)
- Alnus incana / Ribes (inerme, hudsonianum, lacustre) Shrubland (G3, CEGL001151)
- Alnus incana / Scirpus microcarpus Shrubland (G2G3, CEGL000481)
- Alnus incana / Spiraea douglasii Shrubland (G3, CEGL001152)
- Alnus incana / Symphoricarpos albus Shrubland (G3G4, CEGL001153)
- Alnus incana Shrubland (G?Q, Mountain Alder Shrubland, CEGL001141)
- Alnus incana ssp. tenuifolia - Salix irrorata Shrubland (G3, CEGL002687)
- Alnus oblongifolia / Symphoricarpos oreophilus Shrubland (GU, CEGL001063)
- Alnus viridis ssp. sinuata / Athyrium filix-femina - Cinna latifolia Shrubland (G4, CEGL001156)
- Alnus viridis ssp. sinuata Shrubland [Placeholder] (G?Q, Wavyleaf Alder Shrubland, CEGL001154)
- Betula nana / Mesic Forbs - Mesic Graminoids Shrubland (G3G4, CEGL002653)
- Betula occidentalis - Dasiphora fruticosa ssp. floribunda Shrubland (G2Q, Water Birch - Shrubby-cinquefoil Shrubland, CEGL001083)
- Betula occidentalis / Cornus sericea Shrubland (G3, Water Birch / Red-osier Dogwood Shrubland, CEGL001161)
- Betula occidentalis / Maianthemum stellatum Shrubland (G4?, CEGL001162)
- Betula occidentalis / Mesic Graminoids Shrubland (G3, CEGL002654)

- Betula occidentalis Shrubland (G3Q, Water Birch Shrubland, CEGL001080)
- Cornus sericea / Galium triflorum Shrubland (G3?, CEGL001166)
- Cornus sericea / Heracleum maximum Shrubland (G3, CEGL001167)
- Cornus sericea Shrubland (G4Q, Red Osier Dogwood Shrubland, CEGL001165)
- Corylus cornuta Shrubland (G3, CEGL002903)
- Dasiphora fruticosa ssp. floribunda / Deschampsia caespitosa Shrubland (G4, Shrubby-cinquefoil / Tufted Hairgrass Shrub Prairie, CEGL001107)
- Fraxinus anomala Woodland (L, GUQ, Anomalous Ash Woodland, CEGL002752)
- Ribes lacustre - Ribes hudsonianum / Cinna latifolia Shrubland (G2, CEGL003445)
- Ribes lacustre - Ribes hudsonianum / Glyceria striata Shrubland (G2G3, CEGL003446)
- Ribes lacustre / Mertensia ciliata Shrubland (G1G2Q, CEGL001172)
- Salix (boothii, geyeriana) / Carex aquatilis Shrubland (G3, CEGL001176)
- Salix bebbiana / Mesic Graminoids Shrubland (G3?, CEGL001174)
- Salix bebbiana Shrubland (G3?, Beaked Willow Scrub, CEGL001173)
- Salix boothii - Salix eastwoodiae / Carex nigricans Shrubland (G3, CEGL002607)
- Salix boothii - Salix geyeriana / Carex angustata Shrubland (G2, CEGL001185)
- Salix boothii - Salix geyeriana Shrubland (GU, CEGL001184)
- Salix boothii - Salix lemmonii Shrubland (G3, CEGL001186)
- Salix boothii / Calamagrostis canadensis Shrubland (G3G4Q, CEGL001175)
- Salix boothii / Carex nebrascensis Shrubland (G4G5, CEGL001177)
- Salix boothii / Carex utriculata Shrubland (G4, CEGL001178)
- Salix boothii / Deschampsia caespitosa - Geum rossii Shrubland (G4, CEGL002904)
- Salix boothii / Equisetum arvense Shrubland (G3, CEGL002671)
- Salix boothii / Maianthemum stellatum Shrubland (G3Q, CEGL001187)
- Salix boothii / Mesic Forbs Shrubland (G3, CEGL001180)
- Salix boothii / Mesic Graminoids Shrubland (G3?, CEGL001181)
- Salix boothii / Poa palustris Shrubland (GW, CEGL001183)
- Salix brachycarpa / Carex aquatilis Shrubland (G2G3, CEGL001244)
- Salix brachycarpa / Mesic Forbs Shrubland (G4, CEGL001135)
- Salix candida / Carex utriculata Shrubland (G2, Sage Willow Fen, CEGL001188)
- Salix commutata / Carex scopulorum Shrubland (G3, CEGL001189)
- Salix drummondiana / Calamagrostis canadensis Shrubland (G3, Drummond's Willow / Bluejoint Reedgrass, CEGL002667)
- Salix drummondiana / Carex scopulorum var. prionophylla Shrubland (G2G3, CEGL001584)
- Salix drummondiana / Carex utriculata Shrubland (G4, CEGL002631)
- Salix drummondiana / Mesic Forbs Shrubland (G4, CEGL001192)
- Salix drummondiana Shrubland [Placeholder] (G3Q, Drummond's Willow Shrubland, CEGL001190)
- Salix eriocephala / Ribes aureum - Rosa woodsii Shrubland (G3, CEGL001233)
- Salix geyeriana - Salix eriocephala Shrubland (GU, CEGL001213)
- Salix geyeriana - Salix lemmonii / Carex aquatilis var. dives Shrubland (G3, CEGL001212)
- Salix geyeriana - Salix monticola / Calamagrostis canadensis Shrubland (G3, CEGL001247)
- Salix geyeriana - Salix monticola / Mesic Forbs Shrubland (G3, CEGL001223)
- Salix geyeriana / Calamagrostis canadensis Shrubland (G5, Geyer's Willow / Bluejoint Shrubland, CEGL001205)
- Salix geyeriana / Carex aquatilis Shrubland (G3, CEGL001206)
- Salix geyeriana / Carex utriculata Shrubland (G5, Geyer's Willow / Beaked Sedge Shrubland, CEGL001207)
- Salix geyeriana / Deschampsia caespitosa Shrubland (G4, Geyer's Willow / Tufted Hairgrass Shrubland, CEGL001208)
- Salix geyeriana / Mesic Forbs Shrubland (G3, CEGL002666)
- Salix geyeriana / Mesic Graminoids Shrubland (G3?, CEGL001210)
- Salix geyeriana / Poa palustris Shrubland (GW, CEGL001211)
- Salix glauca / Deschampsia caespitosa Shrubland (G4, CEGL001137)
- Salix lemmonii / Mesic-Tall Forb Shrubland (G3?, CEGL002771)
- Salix lemmonii / Rosa woodsii Shrubland (G3, Lemmon's Willow Bench, CEGL002772)
- Salix ligulifolia / Carex utriculata Shrubland [Provisional] (L, G?, CEGL002975)
- Salix ligulifolia Shrubland (L, G2G3, CEGL001218)
- Salix lucida ssp. caudata / Rosa woodsii Shrubland (G3, CEGL002621)

- Salix lucida ssp. caudata Shrubland [Placeholder] (G3Q, Shining Willow Shrubland, CEGL001215)
- Salix lutea / Calamagrostis canadensis Shrubland (G3?, Yellow Willow / Bluejoint Shrubland, CEGL001219)
- Salix lutea / Carex utriculata Shrubland (G4, Yellow Willow / Beaked Sedge Shrubland, CEGL001220)
- Salix lutea / Mesic Forb Shrubland (G3?, CEGL002774)
- Salix lutea / Rosa woodsii Shrubland (G3, CEGL002624)
- Salix monticola / Angelica ampla Shrubland (G?, CEGL001221)
- Salix monticola / Calamagrostis canadensis Shrubland (G3, CEGL001222)
- Salix monticola / Carex aquatilis Shrubland (G3, CEGL002656)
- Salix monticola / Carex utriculata Shrubland (G3, CEGL002657)
- Salix monticola / Mesic Forbs Shrubland (G4, CEGL002658)
- Salix monticola / Mesic Graminoids Shrubland (G3, CEGL002659)
- Salix monticola Thicket Shrubland (G2Q, CEGL001139)
- Salix planifolia / Calamagrostis canadensis Shrubland (G4, CEGL001225)
- Salix planifolia / Caltha leptosepala Shrubland (G4, CEGL002665)
- Salix planifolia / Carex aquatilis Shrubland (G5, CEGL001227)
- Salix planifolia / Carex scopulorum Shrubland (G4, CEGL001229)
- Salix planifolia / Deschampsia caespitosa Shrubland (G2G3, CEGL001230)
- Salix planifolia / Mesic Forbs Shrubland (G4, CEGL002893)
- Salix planifolia Shrubland (G4, CEGL001224)
- Salix wolfii / Carex aquatilis Shrubland (G4, Wolf Willow / Aquatic Sedge Shrubland, CEGL001234)
- Salix wolfii / Carex microptera Shrubland (G3Q, CEGL001235)
- Salix wolfii / Carex nebrascensis Shrubland (G3Q, CEGL001236)
- Salix wolfii / Carex utriculata Shrubland (G4, CEGL001237)
- Salix wolfii / Deschampsia caespitosa Shrubland (G3, Wolf Willow / Tufted Hairgrass Shrubland, CEGL001238)
- Salix wolfii / Fragaria virginiana Shrubland (G4?, CEGL001239)
- Salix wolfii / Mesic Forbs Shrubland (G3, CEGL001240)
- Salix wolfii / Poa palustris Shrubland (GW, CEGL001241)
- Salix wolfii / Swertia perennis - Pedicularis groenlandica Shrubland (G2, Wolf Willow / Bog Swertia - Elephant's-head, CEGL001242)

SOURCES

References: Baker 1988, Baker 1989a, Baker 1989b, Baker 1990, CanRock 2002, Comer et al. 2002, Crowe and Clausnitzer 1997, Kittel 1993, Kittel 1994, Kittel et al. 1996, Kittel et al. 1999a, Kittel et al. 1999b, Kovalchik 1987, Kovalchik 1993, Kovalchik 2001, Manning and Padgett 1995, Muldavin et al. 2000a, Nachlinger et al. 2001, Neely et al. 2001, Padgett 1982, Padgett et al. 1988a, Padgett et al. 1988b, Rondeau 2001, Szaro 1989, Tuhy et al. 2002, Walford 1996

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES304.772 INTER-MOUNTAIN BASINS MOUNTAIN MAHOGANY WOODLAND AND SHRUBLAND

304, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Montane [Lower Montane], Lowland [Foothill], Aridic, Cercocarpus ledifolius

Non-Diagnostic Classifiers: Forest and Woodland (Treed), Shrubland (Shrub-dominated), Foothill(s), Piedmont, Plateau, Ridge/Summit/Upper Slope, Side Slope, Temperate [Temperate Continental], Long Disturbance Interval, F-Patch/Medium Intensity

Concept Summary: This ecological system occurs in hills and mountains ranges of the Inter-Mountain Basins from the eastern foothills of the Sierra Nevada northeast to the foothils of the Big Horn Mountains. It typically occurs from 600 m to over 2650 m elevations on rocky outcrops or escarpments and forms small to large patch stands in forested areas. Most stands occur as shrublands on ridges and steep rimrock slopes, but it may occur as a small tree in steppe areas. This system includes both woodlands and shrublands dominated by *Cercocarpus ledifolius. Artemisia tridentata* ssp. *vaseyana, Purshia tridentata,* with species of *Arctostaphylos, Ribes* or *Symphoricarpos* are often present. Scattered junipers or pines may also occur. *Cercocarpus ledifolius* is a slow-

growing, drought-tolerant, species that generally does not resprout after burning and needs the protection from fire that rocky sites provide.

DISTRIBUTION

Divisions: 206?, 304, 306
TNC Ecoregions: 10:P, 11:C, 12:C, 6:P, 9:C
Subnations/Nations: CA:c, ID:?, NV:c, OR:?, UT:c, WY:c

CONCEPT

Associations:

- Artemisia arbuscula - Cercocarpus ledifolius / Pseudoroegneria spicata - Poa secunda Shrubland (G4Q, CEGL001487)
- Cercocarpus ledifolius / Artemisia tridentata ssp. vaseyana Woodland (G3, CEGL001022)
- Cercocarpus ledifolius / Artemisia tridentata Woodland (G3G4, CEGL000960)
- Cercocarpus ledifolius / Calamagrostis rubescens Woodland (G2, Curl-leaf Mountain-mahogony / Pinegrass Woodland, CEGL000961)
- Cercocarpus ledifolius / Festuca idahoensis Woodland (G3, CEGL000962)
- Cercocarpus ledifolius / Holodiscus dumosus Woodland (G1G2, Curl-leaf Mountain-mahogany / Oceanspray, CEGL000963)
- Cercocarpus ledifolius / Leymus salinus ssp. salmonis Woodland (G2Q, CEGL000964)
- Cercocarpus ledifolius / Mahonia repens Shrubland (G?, CEGL000965)
- Cercocarpus ledifolius / Prunus virginiana Shrubland (G4, CEGL000966)
- Cercocarpus ledifolius / Pseudoroegneria spicata - Festuca idahoensis Woodland (G3G4, CEGL000968)
- Cercocarpus ledifolius / Pseudoroegneria spicata Shrubland (G4Q, CEGL000967)
- Cercocarpus ledifolius / Symphoricarpos longiflorus Shrubland (G4, CEGL000969)
- Cercocarpus ledifolius / Symphoricarpos oreophilus Woodland (G2, CEGL000970)
- Cercocarpus ledifolius Woodland [Placeholder] (G4?, CEGL003038)

SOURCES

References: Knight 1994, Knight et al. 1987, Lewis 1975, Mueggler and Stewart 1980
Last updated: 20 Feb 2003 **Stakeholders:** WCS
Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

In BLUE, unmapped types which occur on the Umatilla National Forest

CES304.770 COLUMBIA PLATEAU SCABLAND SHRUBLAND

304, Shrubland

Spatial Scale & Pattern: Matrix **Classification Confidence:** medium
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Lowland [Lowland], Shrubland (Shrub-dominated), Basalt, Shallow Soil
Non-Diagnostic Classifiers: Plain, Plateau, Toeslope/Valley Bottom, Temperate [Temperate Continental], Aridic

Concept Summary: This ecological system is found in the Columbia Plateau region and forms extensive low shrublands. These xeric shrubland occurs under relatively extreme soil-moisture conditions. Substrates are typically shallow lithic soils with limited water-holding capacity over fractured basalt. Because of poor drainage through basalt these soils are often saturated from fall to spring by winter precipitation, but typically dry out completely to bedrock by midsummer. Vegetation is characterized by an open dwarf-shrub canopy dominated by *Artemisia rigida or A. arbuscula* ssp. *longiloba* along with other shrub and dwarf-shrub species, particularly *Eriogonum* spp. Low cover of perennial bunchgrasses such as *Danthonia unispicata, Elymus elymoides, Festuca idahoensis,* or *Poa secunda* as well as scattered forbs including species of *Allium, Antennaria, Balsamorhiza, Lomatium, Phlox* and *Sedum*. Annuals may be seasonally abundant, and cover of moss and lichen is often high in undisturbed areas (1-60% cover).

DISTRIBUTION

Divisions: 304
TNC Ecoregions: 6:C, 68:C, 7:C
Subnations/Nations: ID:c, NV:c, OR:c, UT:p, WA:c

CONCEPT

Associations:
- Artemisia arbuscula ssp. longiloba / Festuca idahoensis Shrub Herbaceous Vegetation (G3, CEGL001522)
- Artemisia arbuscula ssp. longiloba / Poa secunda Shrub Herbaceous Vegetation (G3Q, CEGL001523)
- Artemisia arbuscula ssp. longiloba Shrubland (G4G5, CEGL001414)
- Artemisia rigida / Festuca idahoensis Shrub Herbaceous Vegetation [Provisional] (G2, CEGL002995)
- Artemisia rigida / Poa secunda Shrub Herbaceous Vegetation (G4, CEGL001528)
- Artemisia rigida / Pseudoroegneria spicata Shrub Herbaceous Vegetation (G3, CEGL001529)
- Danthonia californica - Festuca idahoensis Herbaceous Vegetation (G1Q, CEGL001607)
- Danthonia unispicata - Poa secunda Herbaceous Vegetation (G3, CEGL001783)
- Eriogonum compositum / Poa secunda Dwarf-shrub Herbaceous Vegetation (G2, CEGL001784)
- Eriogonum douglasii / Poa secunda Dwarf-shrub Herbaceous Vegetation (G4, CEGL001785)
- Eriogonum microthecum - Physaria oregona Dwarf-shrubland (G2, CEGL001737)
- Eriogonum niveum / Poa secunda Dwarf-shrub Herbaceous Vegetation (G3, CEGL001786)
- Eriogonum sphaerocephalum / Poa secunda Dwarf-shrub Herbaceous Vegetation (G3, CEGL001448)
- Eriogonum strictum / Poa secunda Dwarf-shrub Herbaceous Vegetation (G3, CEGL001788)
- Eriogonum thymoides / Poa secunda Dwarf-shrub Herbaceous Vegetation (G3, CEGL001449)

SOURCES

References: Daubenmire 1970, Johnson and Simon 1985
Last updated: 20 Feb 2003 **Stakeholders:** WCS
Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.994 NORTHERN ROCKY MOUNTAIN LOWER MONTANE MESIC DECIDUOUS SHRUBLAND

306, Shrubland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** low
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Montane [Lower Montane], Lowland [Foothill], Shrubland (Shrub-dominated), Very Shallow Soil, Broad-Leaved Deciduous Shrub, Moderate (100-500 yrs) Persistence
Non-Diagnostic Classifiers: Montane, Side Slope, Toeslope/Valley Bottom, Temperate, Temperate [Temperate Continental], Ustic

Concept Summary: This shrubland system is found in the lower montane and foothill regions around the Columbia Basin, and north and east into the northern Rockies. These shrublands are usually found on steep slopesof canyons, and in areas with some soil development, either loess deposits or volcanic clays, they occurr on all aspects. Fire, flooding and erosion all impact these shrublands, but they typically will perist on sites for long periods. These communities develop near talus slopes as garlands, at the heads of dry drainages, and toeslopes in the moist shrub steppe and steppe zones. *Physocarpus malvaceus, Prunus emarginata, Prunus virginiana*, and *Holodiscus discolor* are the most common dominant shrubs. In moist areas, *Symphoricapos albus, Crateagus douglasii*, or *Rosa* spp. are generally dominant.*Festuca idahoensis, Koeleria macrantha, Pseudoregnaria spicata*, and *Poa secunda* are the most important grasses. *Achnatherum thurberianum*, and *Leymus cinereus* can be locally important. *Poa pratensis* is a common introduced grass.*Geum triflorum, Potentilla gracilis, Lomatium triternatum, Balsamorhiza sagittata* and species of *Eriogonum, Phlox*, and *Erigeron* are important forbs.

DISTRIBUTION

Divisions: 304, 306
TNC Ecoregions: 6:C, 68:C, 7:C, 8:C
Subnations/Nations: AB:p, BC:p, ID:c, MT:c, OR:c, WA:c

CONCEPT

Associations:
- Crataegus douglasii / Rosa woodsii Shrubland (G2, Black Hawthorn - Woods' Rose Shrubland, CEGL001095)
- Holodiscus discolor Shrubland [Placeholder] (G4?, CEGL003053)
- Physocarpus malvaceus - Symphoricarpos albus Shrubland (G3, CEGL001171)
- Prunus virginiana - (Prunus americana) Shrubland (G4Q, Choke Cherry - (American Plum) Shrubland, CEGL001108)
- Rhamnus alnifolia Shrubland (G3, CEGL001132)
- Rhus glabra / Aristida purpurea var. longiseta Shrub Herbaceous Vegetation (G1, Smooth Sumac / Red Three-awn Shrubland, CEGL001507)
- Rhus glabra / Pseudoroegneria spicata Shrub Herbaceous Vegetation (G2, CEGL001122)
- Rosa woodsii Shrubland (G5, Wood Wild Rose Shrubland, CEGL001126)
- Spiraea douglasii Shrubland (G5, CEGL001129)
- Symphoricarpos albus - Rosa nutkana Shrubland (G3, CEGL001130)

SOURCES

References: Franklin and Dyrness 1973, Hall 1973, Johnson and Clausnitzer 1992, Johnson and Simon 1987, Poulton 1955, Tisdale 1986
Last updated: 23 Mar 2003 **Stakeholders:** WCS, CAN
Concept Author: M. Reid, J. Kagan **LeadResp:** WCS

CES306.836 NORTHERN ROCKY MOUNTAIN MONTANE GRASSLAND

306, Herbaceous

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Herbaceous, Loam Soil Texture, Silt Soil Texture, Ustic, Graminoid, Cool-season bunchgrasses

Non-Diagnostic Classifiers: Montane [Montane], Montane [Lower Montane], Temperate, Temperate [Temperate Continental], Mesotrophic Soil, Shallow Soil, Short Disturbance Interval, F-Patch/Low Intensity, Moderate (100-500 yrs) Persistence

Concept Summary: This ecological system of the northern Rocky Mountains is found at montane elevation in the mountains of northeastern Wyoming, and Montana west through Idaho into the Blue Mountains of Oregon and north into the Okanagan, and the Canadian Rockies. These dry grasslands are small meadows to large open parks surrounded by conifer trees but lack tree cover within them. Generally, the soil textures are much finer and soils are often deeper under grasslands than in the neighboring forests. These northern montane grasslands represent a shift in precipitation regime from summer monsoons and cold snowy winters found in the southern Rockies, to predominantly dry summers and winter rains. Montane Grasslands are very similar and intergrade with their subalpine counterparts, but are separated here to represent those species that do not occur at higher altitudes. Occurrences have a moderately dense graminoid layer of cool season, medium-tall bunchgrasses, dominated by

Festuca campestris, Pseudoroegneria spicata, Festuca idahoensis, Leymus cinereus, Elymus trachycaulus, Bromus pumpellianus, Stipa richardsonii, S. occidentalis, Koeleria macrantha, and other graminoids such as *Carex filifolia, Danthonia intermedia*. Common associated forbs include *Geum triflorum, Galium boreale, Campanula rotundifolia, Antennaria microphylla, Geranium viscosissimum*,and *Potentilla gracilis*. Shrub cover is generally nonexistent, but can be adjacent in neighboring wetlands or riparian areas.

DISTRIBUTION

Divisions: 204, 306
TNC Ecoregions: 6:C, 68:C, 7:C, 8:C, 9:C
Subnations/Nations: AB:c, BC:c, ID:c, MT:c, OR:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Carex hoodii - Festuca idahoensis Herbaceous Vegetation (G2, CEGL001595)
- Dasiphora fruticosa ssp. floribunda / Festuca campestris Shrub Herbaceous Vegetation (G4, Shrubby-cinquefoil / Prairie Fescue Shrub Prairie, CEGL001503)
- Dasiphora fruticosa ssp. floribunda / Festuca idahoensis Shrub Herbaceous Vegetation (G4, Shrubby-cinquefoil / Idaho Fescue Shrub Prairie, CEGL001502)
- Festuca altaica - Pseudoroegneria spicata Herbaceous Vegetation (G4, Rough Fescue - Bluebunch Wheatgrass Mixedgrass Prairie, CEGL001629)
- Festuca idahoensis - Achnatherum richardsonii Herbaceous Vegetation (G3, CEGL001625)
- Festuca idahoensis - Carex filifolia Herbaceous Vegetation (G3, Idaho Fescue - Thread-leaf Sedge Meadow, CEGL001898)
- Festuca idahoensis - Carex hoodii Herbaceous Vegetation (G3G4, CEGL001609)
- Festuca idahoensis - Carex inops ssp. heliophila Herbaceous Vegetation (G3, Idaho Fescue - Sedge Mixedgrass Prairie, CEGL001610)
- Festuca idahoensis - Carex obtusata Herbaceous Vegetation (G3Q, CEGL001611)
- Festuca idahoensis - Carex scirpoidea Herbaceous Vegetation (G2Q, Idaho Fescue - Canadian Single-spike Sedge Meadow, CEGL001899)
- Festuca idahoensis - Danthonia intermedia Herbaceous Vegetation (G3?, CEGL001612)
- Festuca idahoensis - Delphinium glareosum Herbaceous Vegetation (G2, CEGL001613)
- Festuca idahoensis - Koeleria macrantha Herbaceous Vegetation (G3Q, CEGL001620)
- Festuca idahoensis - Leucopoa kingii Herbaceous Vegetation (G2?, CEGL001901)
- Festuca idahoensis - Pascopyrum smithii Herbaceous Vegetation (G4, Idaho Fescue - Western Wheatgrass Mixedgrass Prairie, CEGL001621)
- Festuca idahoensis - Phlox diffusa ssp. longistylis Herbaceous Vegetation (G2, CEGL001622)
- Festuca idahoensis - Potentilla diversifolia Herbaceous Vegetation (G3, CEGL001623)
- Festuca idahoensis - Pseudoroegneria spicata Herbaceous Vegetation (G4, Idaho Fescue - Bluebunch Wheatgrass Mixedgrass, CEGL001624)
- Festuca idahoensis - Symphoricarpos albus Herbaceous Vegetation (G1, Idaho Fescue - Common Snowberry Sparse Dwarf-shrubland, CEGL001509)
- Festuca idahoensis Herbaceous Vegetation (G3Q, CEGL001897)
- Festuca viridula - Festuca idahoensis Herbaceous Vegetation (G2?Q, Green Fescue - Idaho Fescue, CEGL001633)
- Leymus cinereus Herbaceous Vegetation (G2G3Q, Basin Wild Rye Tallgrass Prairie, CEGL001479)
- Leymus salinus ssp. salmonis - Enceliopsis nudicaulis Sparse Vegetation (L, G2Q, CEGL001642)
- Leymus salinus ssp. salmonis - Lupinus argenteus Sparse Vegetation (L, G2Q, CEGL001643)
- Pseudoroegneria spicata - Carex filifolia Herbaceous Vegetation (G4, Bluebunch Wheatgrass - Thread-Leaved Sedge Mixed Prairie, CEGL001665)

Dynamics: *Festuca campestris* is highly palatable throughout the grazing season. Summer overgrazing for 2 to 3 years can result in the loss of Festuca campestris in the stand. Although a light stocking rate for 32 years did not affect range condition, a modest increase in stocking rate led to a marked decline in range condition. The major change was a measurable reduction in basal area of *Festuca campestris*. Long-term heavy grazing on moister sites can result in a shift to a Kentucky bluegrass - timothy type. *Pseudoroegneria spicata* shows an inconsistent reaction to grazing, increasing on some grazed sites while decreasing on others. It seems to recover more quickly from overgrazing than *Festuca campestris*. It tolerates dormant-period grazing well, but is sensitive to defoliation during the growing season. Light spring use or fall grazing can help retain plant vigor. It is particularly sensitive to

defoliation in late spring. Exotic species threatening this ecological system through invasion and potential complete replacement of native species include *Bromus japonicus, Potentilla recta, Euphorbia esula* and all manner of knapweed, especially *Centaurea maculosa*.

SOURCES

References: CanRock 2002, Marriott 2000, McLean 1970, Meidinger and Pojar 1991, Mueggler and Harris 1969, Mueggler and Stewart 1980, Tisdale 1947, Tisdale 1982

Last updated: 02 Mar 2003 **Stakeholders:** WCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES306.813 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND

306, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Forest and Woodland (Treed), Long Disturbance Interval, F-Patch/Medium Intensity, F-Landscape/Medium Intensity, Broad-Leaved Deciduous Tree, Populus tremuloides

Non-Diagnostic Classifiers: Montane [Upper Montane], Montane [Montane], Temperate, Temperate [Temperate Continental], Mesotrophic Soil, Shallow Soil, Mineral: W/ A Horizon <10 cm, Ustic

Concept Summary: This widespread ecological system is more common in the southern and central Rocky Mountains, but occurs throughout much of the western US (including Eastern Cascades) and north into Canada, in the montane and subalpine zones. Elevations generally range from 1525 to 3050 m (5000 to 10,000 feet), but occurrences can be found at lower elevations in some regions. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand, and secondarily is limited by the length of the growing season or low temperatures. These are upland forests and woodlands dominated by *Populus tremuloides* without a significant conifer component (<25% relative tree cover). The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. Associated shrub species include *Symphoricarpos* spp., *Rubus parviflorus, Amelanchier alnifolia* and *Arctostaphylos uva-ursi.* Occurrences of this system originate, and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests.

DISTRIBUTION

Divisions: 204, 206, 304, 306

TNC Ecoregions: 1:P, 11:C, 12:P, 18:C, 19:C, 20:C, 21:P, 25:C, 3:C, 4:P, 5:P, 7:C, 8:C, 81:P, 9:C

Subnations/Nations: AB:c, AZ:c, BC:c, CA:c, CO:c, ID:c, MT:c, NM:c, NV:c, OR:c, SD:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Populus tremuloides / Acer glabrum Forest (G1G2, Quaking Aspen / Rocky Mountain Maple, CEGL000563)
- Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Bromus carinatus Forest (G3G5, CEGL000566)
- Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Calamagrostis rubescens Forest (G4, CEGL000567)
- Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Tall Forbs Forest (G5, CEGL000568)
- Populus tremuloides / Amelanchier alnifolia - Symphoricarpos oreophilus / Thalictrum fendleri Forest (G5, CEGL000569)
- Populus tremuloides / Amelanchier alnifolia / Pteridium aquilinum Forest (G2G3, CEGL000565)
- Populus tremuloides / Amelanchier alnifolia / Tall Forbs Forest (G3G5, CEGL000570)
- Populus tremuloides / Amelanchier alnifolia / Thalictrum fendleri Forest (G3G4, CEGL000571)
- Populus tremuloides / Amelanchier alnifolia Forest (G4, Aspen / Saskatoon Serviceberry Forest, CEGL000564)
- Populus tremuloides / Artemisia tridentata Forest (G3G4, CEGL000572)
- Populus tremuloides / Bromus carinatus Forest (G5, CEGL000573)
- Populus tremuloides / Calamagrostis rubescens Forest (G5?, CEGL000575)
- Populus tremuloides / Carex geyeri Forest (G4, Aspen / Elk Sedge Forest, CEGL000579)
- Populus tremuloides / Carex rossii Forest (G5, CEGL000580)
- Populus tremuloides / Carex siccata Forest (G4, CEGL000578)

- Populus tremuloides / Ceanothus velutinus Forest (G2, CEGL000581)
- Populus tremuloides / Corylus cornuta Forest (G3, Aspen / Beaked Hazel Forest, CEGL000583)
- Populus tremuloides / Festuca thurberi Forest (G4, CEGL000585)
- Populus tremuloides / Heracleum sphondylium Forest (G4Q, CEGL000586)
- Populus tremuloides / Hesperostipa comata Forest (G2G4, CEGL000608)
- Populus tremuloides / Juniperus communis / Carex geyeri Forest (G4G5, CEGL000588)
- Populus tremuloides / Juniperus communis / Lupinus argenteus Forest (G3G4, CEGL000589)
- Populus tremuloides / Juniperus communis Forest (G4, CEGL000587)
- Populus tremuloides / Ligusticum filicinum Forest (G4Q, CEGL000591)
- Populus tremuloides / Lonicera involucrata Forest (G3, CEGL000592)
- Populus tremuloides / Lupinus argenteus Forest (G?, CEGL000593)
- Populus tremuloides / Mahonia repens Forest (G3, Aspen / Oregon-grape Forest, CEGL000594)
- Populus tremuloides / Osmorhiza occidentalis Forest (G3, Aspen / Western Sweet-cicely Forest, CEGL000595)
- Populus tremuloides / Prunus virginiana Forest (G3G4, Aspen / Choke Cherry Forest, CEGL000596)
- Populus tremuloides / Pteridium aquilinum Forest (G4, Aspen / Bracken Fern Forest, CEGL000597)
- Populus tremuloides / Quercus gambelii / Symphoricarpos oreophilus Forest (G?, CEGL000598)
- Populus tremuloides / Ribes montigenum Forest (G2, Quaking Aspen / Gooseberry Currant, CEGL000600)
- Populus tremuloides / Rubus parviflorus Forest (G2, Aspen / Thimbleberry Forest, CEGL000602)
- Populus tremuloides / Rudbeckia occidentalis Forest (G?Q, CEGL000603)
- Populus tremuloides / Salix scouleriana Forest (G4, CEGL000604)
- Populus tremuloides / Sambucus racemosa Forest (G2G3, CEGL000605)
- Populus tremuloides / Shepherdia canadensis Forest (G3G4, CEGL000606)
- Populus tremuloides / Spiraea betulifolia Forest (G4Q, Aspen / Shiny-leaf Spiraea Forest, CEGL000607)
- Populus tremuloides / Symphoricarpos albus / Elymus glaucus Woodland (G3, CEGL000946)
- Populus tremuloides / Symphoricarpos albus Forest (G3?, Aspen / Snowberry Forest, CEGL000609)
- Populus tremuloides / Symphoricarpos oreophilus / Bromus carinatus Forest (G5, CEGL000611)
- Populus tremuloides / Symphoricarpos oreophilus / Calamagrostis rubescens Forest (G3G5, CEGL000612)
- Populus tremuloides / Symphoricarpos oreophilus / Carex rossii Forest (G3G4, Aspen / Mountain Snowberry / Ross' Sedge Forest, CEGL000613)
- Populus tremuloides / Symphoricarpos oreophilus / Festuca thurberi Forest (G3?, CEGL000614)
- Populus tremuloides / Symphoricarpos oreophilus / Tall Forbs Forest (G3G5, CEGL000615)
- Populus tremuloides / Symphoricarpos oreophilus / Thalictrum fendleri Forest (G5, CEGL000616)
- Populus tremuloides / Symphoricarpos oreophilus / Wyethia amplexicaulis Forest (G4Q, CEGL000617)
- Populus tremuloides / Symphoricarpos oreophilus Forest (G5, Aspen / Mountain Snowberry Forest, CEGL000610)
- Populus tremuloides / Tall Forbs Forest (G5, CEGL000618)
- Populus tremuloides / Thalictrum fendleri Forest (G5, CEGL000619)
- Populus tremuloides / Vaccinium myrtillus Forest (G3, CEGL000620)
- Populus tremuloides / Wyethia amplexicaulis Forest (G3, CEGL000622)

Environment: Climate is temperate with a relatively long growing season, typically cold winters and deep snow. Mean annual precipitation is greater than 15 inches and typically greater than 20 inches, except in semi-arid environments where occurrences are restricted to mesic microsites such as seeps or large snow drifts. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand (Mueggler 1988). Secondarily, its range is limited by the length of the growing season or low temperatures (Mueggler 1988). Topography is variable, sites range from level to steep slopes. Aspect varies according to the limiting factors. Occurrences at high elevations are restricted by cold temperatures and are found on warmer southern aspects. At lower elevations occurrences are restricted by lack of moisture and are found on cooler north aspects and mesic microsites. The soils are typically deep and well developed with rock often absent from the soil. Soil texture ranges from sandy loam to clay loams. Parent materials are variable and may include sedimentary, metamorphic or igneous rocks, but it appears to grow best on limestone, basalt, and calcareous or neutral shales (Mueggler 1988).

Vegetation: Occurrences have a somewhat closed canopy of trees of 5-20 m tall that is dominated by the cold-deciduous, broad-leaf tree, *Populus tremuloides*. Conifers that may be present but never codominant include *Abies concolor, A. lasiocarpa, Picea engelmannii, P. pungens, P. ponderosa* and *Pseudotsuga menziesii*. Conifer species may contribute up to 15 percent of the tree canopy before the occurrence is reclassified as a mixed occurrence.

Because of the open growth form of *P. tremuloides*, enough light can penetrate for lush understory development. Depending on available soil moisture and other factors like disturbance, the understory structure may be complex with multiple shrub and herbaceous layers, or simple withJust an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs.

Common shrubs include *Acer glabrum, Amelanchier alnifolia, Artemisia tridentata, Juniperus communis, Prunus virginiana, Rosa woodsii, Shepherdia canadensis, Symphoricarpos oreophilus*, and the dwarf shrubs *Mahonia repens* and *Vaccinium spp*. The herbaceous layers may be lush and diverse. Common graminoids may include *Bromus carinatus, Calamagrostis rubescens, Carex foenea, C. geyeri, C. rossii, Elymus glaucus, E. trachycaulus, Festuca thurberi*, and *Hesperostipa comata*. Associated forbs may include *Achillea millefolium, Aster engelmannii, Delphinium* spp., *Geranium viscosissimum, Heracleum sphondylium, Ligusticum filicinum, Lupinus argenteus, Osmorhiza chilensis, Pteridium aquilinum, Rudbeckia occidentalis, Thalictrum fendleri, Valeriana occidentalis, Wyethia amplexicaulis*, and many others. Exotic grasses such as the perennials *Poa pratensis* and *Bromus inermis* and the annual *Bromus tectorum* are often common in occurrences disturbed by grazing.

Dynamics: Occurrences in this ecological system often originate, and are likely maintained, by stand-replacing disturbances such as crown fire, disease and windthrow, or clearcutting by man or beaver. The stems of these thin-barked, clonal trees are easily killed by ground fires, but they can quickly and vigorously resprout in densities of up to 30,000 stems per hectare (Knight 1993). The stems are relatively short-lived (100-150 years) and the occurrence will succeed to longer-lived conifer forest if undisturbed. Occurrences are favored by fire in the conifer zone (Mueggler 1988). With adequate disturbance a clone may live many centuries. Although *Populus tremuloides* produces abundant seeds, seedling survival is rare because of the long moist conditions required to establish are rare in the habitats that it occurs in. Superficial soil drying will kill seedlings (Knight 1993).

SOURCES

References: Bartos 1979, Bartos and Cambell 1998, Bartos and Mueggler 1979, CanRock 2002, Comer et al. 2002, DeByle and Winokur 1985, DeVelice et al. 1986, Henderson et al. 1977, Hess and Wasser 1982, Johnston and Hendzel 1985, Keammerer 1974a, Mueggler 1988, Neely et al. 2001, Powell 1988a, Tuhy et al. 2002, Youngblood and Mauk 1985

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS, CAN

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES304.778 INTER-MOUNTAIN BASINS BIG SAGEBRUSH STEPPE

304, Steppe/Savanna

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Lowland [Lowland], Deep Soil, Aridic, Xeromorphic Shrub, Bunchgrasses, Artemisia tridentata ssp. tridentata

Non-Diagnostic Classifiers: Lowland [Foothill], Woody-Herbaceous, Plain, Plateau, Side Slope, Temperate [Temperate Continental], Alkaline Soil, Forb, Graminoid

Concept Summary: This widespread matrix ecological system occurs throughout much of the Columbia Plateau and northern Great Basin and Wyoming, and is found at slightly higher elevations further south. Soils are typically deep and non-saline often with a microphytic crust. This shrub-steppe is dominated by perennial grasses and forbs (>25% cover) with *Artemisia tridentata ssp. tridentata, A. tridentata ssp. xericensis, A. tridentata ssp. wyomingensis, A. tripartita* ssp. *tripartita* and/or *Purshia tridentata* dominating or codominating the open to moderately dense (10-40% cover) shrub layer. *Atriplex confertifolia, Chrysothamnus viscidiflorus, Ericameria nauseosa, Tetradymia* spp. or *Artemisia frigida* may be common especially in disturbed stands. Associated graminoids include *Achnatherum hymenoides, Calamagrostis montanensis, Elymus lanceolatus* var. *lanceolatus, Festuca idahoensis, F. campestris, Koeleria macrantha, Poa secunda* and *Pseudoroegneria spicata.* Common forbs are *Phlox hoodii, Arenaria* spp., *Astragalus* spp. Areas with deeper soils more commonly support *Artemisia tridentata* ssp. *tridentata,* but have largely been converted for other land uses. Microphytic crust is very important in this ecological system. The natural fire regime of this ecolgical system likely mantains patchy distribution of shrubs so the general aspect of the vegetation is a grassland. Shrubs may increase following heavy grazing and/or with fire suppression, particularly in moist portions in the northern Columbia Plateau where it forms a landscape mosaic pattern with shallow soil scabland shrublands.

DISTRIBUTION

Divisions: 304, 306
TNC Ecoregions: 10:C, 11:C, 20:C, 26:C, 4:C, 6:C, 8:C, 9:C
Subnations/Nations: CA:c, CO:c, ID:c, MT:c, NV:c, OR:c, UT:c, WA:c, WY:c

CONCEPT

Associations:

- Artemisia tridentata (ssp. tridentata, ssp. xericensis) / Pseudoroegneria spicata - Poa secunda Shrub Herbaceous Vegetation (G1, CEGL001019)
- Artemisia tridentata (ssp. tridentata, ssp. xericensis) / Pseudoroegneria spicata Shrub Herbaceous Vegetation (G2G4, Big Sagebrush / Bluebunch Wheatgrass Shrubland, CEGL001018)
- Artemisia tridentata / Festuca idahoensis Shrub Herbaceous Vegetation (G4Q, Big Sagebrush / Idaho Fescue Shrub Prairie, CEGL001530)
- Artemisia tridentata / Leymus cinereus Shrub Herbaceous Vegetation (G2G4, CEGL001458)
- Artemisia tridentata / Sporobolus cryptandrus - Achnatherum hymenoides Shrub Herbaceous Vegetation (G2?, Big Sagebrush / Sand Dropseed - Indian Ricegrass, CEGL001545)
- Artemisia tridentata ssp. tridentata - Grayia spinosa Shrubland (G5, CEGL001004)
- Artemisia tridentata ssp. tridentata / Distichlis spicata Shrubland (G5, CEGL001000)
- Artemisia tridentata ssp. tridentata / Festuca idahoensis Shrubland (G4?, Big Sagebrush / Idaho Fescue Shrubland, CEGL001014)
- Artemisia tridentata ssp. tridentata / Hesperostipa comata Shrubland (G4?, CEGL002966)
- Artemisia tridentata ssp. tridentata / Leymus cinereus Shrubland (G2, CEGL001016)
- Artemisia tridentata ssp. tridentata / Pascopyrum smithii - (Elymus lanceolatus) Shrubland (G3?, CEGL001017)
- Artemisia tridentata ssp. tridentata / Pleuraphis jamesii Shrubland (G2G4, CEGL001015)
- Artemisia tridentata ssp. tridentata / Poa secunda Shrubland (G3G5, CEGL001008)
- Artemisia tridentata ssp. wyomingensis / Mixed Grasses Shrub Herbaceous Vegetation (G5, Big Sagebrush / Mixed Grasses Shrub Prairie, CEGL001534)
- Artemisia tridentata ssp. wyomingensis / Pascopyrum smithii Shrub Herbaceous Vegetation (G4, Wyoming Sagebrush / Western Wheatgrass Shrubland, CEGL001047)
- Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrub Herbaceous Vegetation (G4, Big Sagebrush / Bluebunch Wheatgrass Shrub Prairie, CEGL001535)
- Artemisia tripartita ssp. tripartita / Festuca campestris Shrub Herbaceous Vegetation (G2?, CEGL001537)
- Artemisia tripartita ssp. tripartita / Festuca idahoensis Shrub Herbaceous Vegetation (G3, CEGL001536)
- Artemisia tripartita ssp. tripartita / Hesperostipa comata Shrub Herbaceous Vegetation (G1, Threetip Sagebrush / Needle-and-Thread, CEGL001539)
- Artemisia tripartita ssp. tripartita / Leymus cinereus Shrub Herbaceous Vegetation [Provisional] (GU, CEGL002994)
- Artemisia tripartita ssp. tripartita / Pseudoroegneria spicata Shrub Herbaceous Vegetation (G2G3, CEGL001538)
- Purshia tridentata / Festuca campestris Shrub Herbaceous Vegetation (G2?, CEGL001494)
- Purshia tridentata / Festuca idahoensis Shrub Herbaceous Vegetation (G3G5, CEGL002674)
- Purshia tridentata / Hesperostipa comata Shrub Herbaceous Vegetation (G2, Antelope Bitterbrush / Needle-and-Thread, CEGL001498)
- Purshia tridentata / Poa secunda Shrubland (G1?Q, CEGL001059)
- Purshia tridentata / Pseudoroegneria spicata Shrub Herbaceous Vegetation (G3, CEGL001495)

Dynamics: The natural fire regime of this ecolgical system likely mantains patchy distribution of shrubs so the general aspect of the vegetation is a grassland. Shrubs may increase following heavy grazing and/or with fire suppression, particularly in moist portions in the northern Columbia Plateau where it forms a landscape mosaic pattern with shallow soil scabland shrublands. Microphytic crust is very important in this ecological system.

SOURCES

References: Barbour and Major 1977, Barbour and Major 1988, Daubenmire 1970, Knight 1994, Mueggler and Stewart 1980, West 1983c

Last updated: 20 Feb 2003 **Stakeholders:** WCS, MCS
Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES204.854 NORTH PACIFIC AVALANCHE CHUTE AND TALUS SHRUBLAND

204, Shrubland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Montane [Montane], Shrubland (Shrub-dominated), Talus (Substrate), Avalanche
Non-Diagnostic Classifiers: Montane [Upper Montane], Montane [Lower Montane], Temperate, Temperate [Temperate Continental]

Concept Summary: This tall shrubland system occurs throughout mountainous regions of the Pacific Northwest, from the southern Cascade and Coast Ranges north to south-central Alaska. This system occurs on sideslopes of hills or mountains on glacial till orcolluvium. These habitats range from moderately xeric to wet and occur on talus or avalanche chutes, often but not exclusively at montane elevations.. In the mountains of Washington, talus sites and snow avalanche chutues very often coincide spatially. Stands are dominated by *Acer circinatum, Alnus sinuata* or *Salix* species. *Acer circinatum* communities are known from the montane *Tsuga heterophylla* zone and continue well into the *Abies amabilis* zone, and intergrade with the wetter *Alnus sinuata* communities that occur where there is heavy snowpack accumlation. The main feature of these shrublands is they occur on steep, frequently (snow avalanches) or intensely (talus) disturbed slopes. The distubance can be moving snow (avalanches), mud (mass wasting), rock slide (thus creating talus), or (less so) exposed and eroding soil due to fire. Avalanche chutes can be quite long, extending from the subalpine into the montane and foothill toeslopes. Talus or scree slopes have a great variety of stand composition and structure depending on substrate, elevation, and exposure. Both are localized conspicuous features of the landscape of steep and rugged mountians.

DISTRIBUTION

Divisions: 204
TNC Ecoregions: 1:, 3:, 4:, 69:, 70:, 81:
Subnations/Nations: BC:, OR:, WA:

CONCEPT

Associations:
- Alnus viridis ssp. sinuata / Acer circinatum Shrubland (G4G5, CEGL001155)

Alaska & Pacific Northwest community types:
- Alnus crispa ssp. sinuata/Athyrium filix-femina (IIB1B)
- Alnus crispa ssp. sinuata/Calamagrostis canadensis (IIB1B)
- Alnus crispa ssp. sinuata/Dryopteris dilatata (IIB1B)
- Alnus crispa ssp. sinuata-Oplopnax horridus (IIB1B)
- Alnus crispa ssp. sinuata-Salix alaxensis (IIB1D)
- Alnus crispa ssp. sinuata-Salix alaxensis/Calamagrostis canadensis (IIB1D)
- Alnus crispa ssp. sinuata-Salix barclayi (IIB1D)
- Alnus crispa ssp. sinuata-Salix sitchensis (IIB1D)
- Alnus crispa ssp. sinuata-Salix sitchensis/Calamagrostis canadensis (IIB1D)
- Alnus crispa/Artemisia tilesii-Calamagrostis canadensis (IIB1B?)
- Alnus crispa/Calamagrostis canadensis (IIB2B1)
- Alnus crispa/Rubus spectabilis (Sambucus racemosa/Calamagrostis canadensis-Carex macrochaeta/Cryopteris dilatata-Aconitum maximum) (IIB1B?)
- Alnus crispa/Spiraea beauverdiana (IIB2B3)
- Alnus crispa-Salix planifolia/Artemisia tilesii-Calamagrostis canadensis (IIB1B?)
- Alnus sinuata (IIB1B9)
- Alnus sinuata/Calamagrostis canadensis (IIB1B10)
- Alnus sinuata-Salix barclayi-S. sitchensis (IIB1D6)
- Alnus spp. (IIB2B?)
- Alnus spp./Calamagrostis canadensis (IIB2D?)
- Alnus spp./forbs (IIB1B?)
- Alnus spp/Spirea beauverdiana-Vaccinium vitis-idaea/Calamagrostis canadensis (IIB1B)
- Alnus tenuifolia (IIB1B12)
- Alnus tenuifolia/Calamagrostis canadensis (IIB1B13)
- Alnus tenuifolia-Salix alaxensis/Calamagrostis canadensis (IIB1D5)

- Salix alaxensis (IIB1A1)
- Salix alaxensis -S. arbusculoides /Calamagrostis canadensis-Equisetum pratense (IB1A9)
- Salix alaxensis -S. arbusculoides /Calamagrostis canadensis-forbs (IB1A?)
- Salix alaxensis/Calamagrostis canadensis (IIB1A)
- Salix alaxensis/Calamagrostis spp.-Equisetum arvense (IIB1A2)
- Salix alaxensis-S. arbusculoides-S. glauca/Equisetum arvense-Pyrola grandiflora (IIB1A8)
- Salix alaxensis-S. planifolia (IIB1A6)
- Salix barclayi (IIB1A12)
- Salix barclayi/Mixed Herbs (IIB1A20)
- Salix barclayi-Salix arctica/Heracleum lanatum-Saxifraga punctata-Solidago multiradiata/lichens (IIB1A??)
- Salix planifolia (IIB1A10)
- Salix sitchensis (IIB1A13) ??? WESTERN WA VERSION IS A WETLAND NOT ON SLOPES
- Salix spp./Betula glandulosa-Vaccinium uliginosum/Calamagrostis canadensis (IIB2A?)

SOURCES

References: Boggs 2000, Franklin and Dyrness 1973, Viereck et al. 1992
Last updated: 06 Mar 2003 **Stakeholders:** WCS
Concept Author: K. Boggs and G. Kittel **LeadResp:** WCS

CES306.830 ROCKY MOUNTAIN SUBALPINE MESIC SPRUCE-FIR FOREST AND WOODLAND

306, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** medium
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Montane [Upper Montane], Forest and Woodland (Treed), Acidic Soil, Udic, Very Long Disturbance Interval [Seasonality/Summerr Disturbance], F-Patch/High Intensity, F-Landscape/Medium Intensity, Abies lasiocarpa - Picea engelmannii, RM Subalpine Dry-Mesic Spruce-Fir, Long (> 500 yrs) Persistence

Non-Diagnostic Classifiers: Montane [Montane], Side Slope, Toeslope/Valley Bottom, Temperate, Temperate [Temperate Continental], Mesotrophic Soil, Shallow Soil, Mineral: W/ A Horizon >10 cm

Concept Summary: This is a high elevation system of the Rocky Mountains, dominated by *Picea engelmannii* and *Abies lasiocarpa*. Occurrences are typically found in locations with cold air drainage or ponding, or where snow-packs linger late into the summer, such as north-facing slopes and high elevation ravines. They can extend down in elevation below the subalpine zone in places where cold air ponding occurs; northerly and easterly aspects predominate. These forests are found on gentle to very steep mountain slopes, high elevation ridgetops and upper slopes, plateaulike surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. Mesic understory shrubs include, *Rhododendron albiflorum*, *Amelanchier alnifolia*, *Rubus parviflorus*, *Ledum glandulosum*, *Phyllodoce empetriformis*, and *Salix* spp. Herbaceous species include *Actaea rubra*, *Maianthemum stellatum*, *Cornus canadensis*, *Erigeron eximius*, *Saxifraga bronchialis*, *Luzula glabrata var. hitchcockii*, or *Calamagrostis canadensis*. Disturbances include occasional blow-down, insect outbreaks and stand-replacing fire.

DISTRIBUTION

Divisions: 204, 304, 306
TNC Ecoregions: 11:C, 20:C, 21:C, 4:C, 68:C, 7:C, 8:C, 9:C
Subnations/Nations: AB:c, AZ:c, BC:c, CO:c, ID:c, MT:c, NM:c, NV:c, OR:c, UT:c, WA:c, WY:c

CONCEPT

Associations:
- Abies lasiocarpa - Picea engelmannii Ribbon Forest (GUQ, CEGL000328)
- Abies lasiocarpa / Acer glabrum Forest (G5, CEGL000294)
- Abies lasiocarpa / Actaea rubra Forest (G4?, Subalpine Fir / Baneberry Forest, CEGL000295)
- Abies lasiocarpa / Calamagrostis canadensis Forest (G5, Subalpine Fir / Bluejoint Forest, CEGL000300)
- Abies lasiocarpa / Caltha leptosepala ssp. howellii Forest (G3?, CEGL000302)
- Abies lasiocarpa / Carex geyeri Forest (G5, CEGL000304)
- Abies lasiocarpa / Clematis columbiana var. columbiana Forest (G3?, Subalpine Fir / Columbia Clematis Forest, CEGL000306)
- Abies lasiocarpa / Coptis occidentalis Forest (G4, CEGL000308)
- Abies lasiocarpa / Cornus canadensis Forest (G3G4, CEGL000309)

- Abies lasiocarpa / Erigeron eximius Forest (G5, CEGL000310)
- Abies lasiocarpa / Gymnocarpium dryopteris Forest (G?Q, CEGL002611)
- Abies lasiocarpa / Ledum glandulosum Forest (G4, CEGL000314)
- Abies lasiocarpa / Luzula glabrata var. hitchcockii Forest (G5, CEGL000317)
- Abies lasiocarpa / Moss Forest (G4, CEGL000321)
- Abies lasiocarpa / Phyllodoce empetriformis Woodland (G4Q, CEGL000920)
- Abies lasiocarpa / Rhododendron albiflorum Woodland (G4, CEGL000330)
- Abies lasiocarpa / Rubus parviflorus Forest (G5, CEGL000332)
- Abies lasiocarpa / Salix brachycarpa Shrubland (GUQ, CEGL000986)
- Abies lasiocarpa / Salix glauca Shrubland (GUQ, CEGL000987)
- Abies lasiocarpa / Vaccinium membranaceum / Valeriana sitchensis Forest (G4, CEGL002612)
- Abies lasiocarpa / Vaccinium membranaceum Forest (G4, CEGL000342)
- Abies lasiocarpa / Vaccinium membranaceum Rocky Mountain Forest (G5, Subalpine Fir / Square-twig Blueberry Forest, CEGL000341)
- Picea engelmannii / Acer glabrum Forest (G2, CEGL000354)
- Picea engelmannii / Hypnum revolutum Forest (G3, CEGL000368)
- Picea engelmannii / Maianthemum stellatum Forest (G4?, Engelmann Spruce / False Lily-of-the-Valley Forest, CEGL000415)
- Picea engelmannii / Moss Forest (G4, CEGL000371)
- Picea engelmannii / Packera cardamine Forest (G2, CEGL000375)
- Picea engelmannii / Physocarpus malvaceus Forest (G3, CEGL002676)
- Populus tremuloides - Abies lasiocarpa / Amelanchier alnifolia Forest (G3?, CEGL000524)
- Populus tremuloides - Abies lasiocarpa / Carex geyeri Forest (G3?, CEGL000525)
- Populus tremuloides - Abies lasiocarpa / Juniperus communis Forest (G3G4, CEGL000527)

SOURCES

References: Alexander et al. 1984a, Alexander et al. 1987, CanRock 2002, Comer et al. 2002, Cooper et al. 1987, Daubenmire and Daubenmire 1968, DeVelice et al. 1986, Graybosch and Buchanan 1983, Hess and Alexander 1986, Hess and Wasser 1982, Hoffman and Alexander 1976, Hoffman and Alexander 1980, Hoffman and Alexander 1983, Komarkova et al. 1988b, Mauk and Henderson 1984, Meidinger and Pojar 1991, Muldavin et al. 1996, Neely et al. 2001, Pfister 1972, Pfister et al. 1977, Steele and Geier-Hayes 1995, Steele et al. 1981, Tuhy et al. 2002, Youngblood and Mauk 1985

Last updated: 20 Feb 2003 **Stakeholders:** WCS

Concept Author: NatureServe Western Ecology Team **LeadResp:** WCS

CES204.838 NORTH PACIFIC MOUNTAIN HEMLOCK FOREST

204, Forest and Woodland

Spatial Scale & Pattern: Matrix **Classification Confidence:** high

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland

Diagnostic Classifiers: Forest and Woodland (Treed), Temperate [Temperate Oceanic], Tsuga mertensiana

Non-Diagnostic Classifiers: Montane [Upper Montane], Montane [Montane], Temperate

Concept Summary: This forested system occurs throughout the mountains of the North Pacific, from the northern Cascades of Oregon north to southeast Alaska. It is the predominant forest of subalpine elevations in the coastal mountains of BC, SE Alaska, western Washington and northwestern Oregon. Further south and inland, *Tsuga mertensiana* becomes limited to the coldest and wettest pockets of the more continental subalpine-fir forests, described from the Cascades and Northern Rocky Mountains. This is a moist type with cool summers and very little fire disturbance. It is differentiated from its more southern component, CES206.911North Pacific Mesic Subalpine Woodland, by the presence of *Abies amabilis*. It also occurs on mountain slopes on the outer coastal islands. It lies between the Western Hemlock or Pacific silver fir zone and the Subalpine Parkland or Alpine Tundra zone, elevations ranging from 400 to 1600 m (1300-5300 feet) The lower and upper elevation limits decrease from south to north and from east to west, and it occurs at higher elevations further south. In southern BC it ranges from 900-1600 m, and in Northern BC, from 300-900 m. The climate is characterized by short, cool summers, rainy autumns and long, cool, wet winters with heavy snow cover for 5-9 months. Mountain Hemlock and amabilis fir are the characteristic dominant tree species. *Chameacyparis nootkatensis* is abundant in the more coastal portions, while *Abies lasiocarpa* is found inland, and becomes increasingly common near the transition to the Subalpine-Fir-Englemann

Spruce Zone. *Tsuga heterophylla* typically occurs at lower elevations in this system, but is much less abundant than *Tsuga mertensiana*. *Picea sitchensis* and *Thuja plicata* are occasionally present, especially on the outer coast of Alaska. Deciduous trees are rare. Parklands are not part of this system but the North Pacific Maritime Mesic Parkland.

Divisions: 204, 306
TNC Ecoregions: 1:, 3:, 69:, 7:, 81:
Subnations/Nations: AB:, BC:, ID:, MT:, OR:, WA:

CONCEPT

Associations:

- Chamaecyparis nootkatensis / Oplopanax horridus Forest (G3, CEGL000349)
- Chamaecyparis nootkatensis / Vaccinium ovalifolium Forest (G4Q, CEGL000351)
- Pseudotsuga menziesii - Tsuga mertensiana / Acer circinatum Woodland (G4Q, CEGL000912)
- Tsuga mertensiana - Abies amabilis / Caltha leptosepala ssp. howellii Forest (G3, CEGL000501)
- Tsuga mertensiana - Abies amabilis / Elliottia pyroliflorus Woodland (G3G4, CEGL000503)
- Tsuga mertensiana - Abies amabilis / Oplopanax horridus Forest (G3G4, CEGL000507)
- Tsuga mertensiana - Abies amabilis / Rhododendron albiflorum Forest (G5, CEGL002632)
- Tsuga mertensiana - Abies amabilis / Rhododendron macrophyllum Forest (G4, CEGL000124)
- Tsuga mertensiana - Abies amabilis / Rubus lasiococcus Forest (G3, CEGL000509)
- Tsuga mertensiana - Abies amabilis / Tiarella trifoliata var. unifoliata - Streptopus lanceolatus Forest (G3G4, CEGL000125)
- Tsuga mertensiana - Abies amabilis / Vaccinium membranaceum - Vaccinium ovalifolium Forest (G4G5, CEGL002620)
- Tsuga mertensiana - Abies amabilis / Vaccinium membranaceum - Valeriana sitchensis Forest (G4, CEGL002619)
- Tsuga mertensiana - Abies amabilis / Vaccinium membranaceum - Xerophyllum tenax Forest (G4, CEGL000515)
- Tsuga mertensiana - Abies amabilis / Vaccinium membranaceum Forest (G4?, CEGL002618)

Tsuga mertensiana - Abies amabilis / Vaccinium ovalifolium - Clintonia uniflora Forest (G4G5, CEGL000512)WA, BC (West Cascades)

- Tsuga mertensiana - Abies amabilis / Vaccinium ovalifolium - Erythronium montanum Forest (G3G4, CEGL000513)WA Olympics
- Tsuga mertensiana - Abies amabilis / Vaccinium ovalifolium - Maianthemum dilatatum Forest (G3G4, CEGL002617)WA West Cascades
- Tsuga mertensiana - Chamaecyparis nootkatensis / Gaultheria shallon Woodland (G5, CEGL003214)
- Tsuga mertensiana - Chamaecyparis nootkatensis / Vaccinium ovalifolium Forest (G5, CEGL003208)
- Tsuga mertensiana / Elliottia pyroliflorus Woodland (G4G5, CEGL003248)AK
- Tsuga mertensiana / Rhododendron albiflorum Forest (G?, CEGL000508)WA, BC
- Tsuga mertensiana / Streptopus amplexifolius Forest (G2, Mountain Hemlock / Twisted-stalk, CEGL000511)ID

Tsuga mertensiana / Vaccinium ovalifolium / Caltha leptosepala ssp. howellii Woodland (G5, CEGL003247)AK

- Tsuga mertensiana / Vaccinium ovalifolium / Nephrophyllidium crista-galli Woodland (G5, CEGL003245)AK

Alaska & Pacific Northwest community types:

- Picea sitchensis-Tsuga mertensiana/Vaccinium sp. (AK00029)
- Picea sitchensis-Tsuga mertensiana/Vaccinium sp./Caltha biflora (AK00030)
- Picea sitchensis-Tsuga mertensiana/Vaccinium sp.-Oplopanax horridum (AK00031)
- Tsuga mertensiana/Alnus sinuata (AK00032)
- Tsuga mertensiana/Cassiope sp./Fauria crista-galli (AK00033)
- Tsuga mertensiana/Cassiope stellariana (AK00034)
- Tsuga mertensiana/Cladothamnus pyrolaeflorus (AK00035)
- Tsuga mertensiana/Phyllodoce aleutica/Fauria crista-galli (AK00036)
- Tsuga mertensiana/Vaccinium ovaliflorum-Cassiope stellariana (AK00037)
- Tsuga mertensiana/Vaccinium sp. (AK00038)
- Tsuga mertensiana/Vaccinium sp./Caltha biflora (AK00039)
- Tsuga mertensiana/Vaccinium sp./Fauria crista-galli (AK00040)
- Tsuga mertensiana/Vaccinium uliginosum/Fauria crista-galli (AK00041)
- Tsuga mertensiana-Tsuga heterophylla/Alnus sinuata (AK00042)
- Tsuga mertensiana-Tsuga heterophylla/Vaccinium sp. (AK00043)
- Tsuga mertensiana-Tsuga heterophylla/Vaccinium sp./Fauria crista galli (AK00044)

- Tsuga mertensiana-Tsuga heterophylla/Vaccinium sp./Lysichiton americanum (AK00045)
- Tsuga mertensiana-Tsuga heterophylla/Vaccinium sp.-Menziesia ferruginea (AK00046)

SOURCES

References: Franklin 1988, Klinka and Chourmouzis 2002
Last updated: 05 Mar 2003 **Stakeholders:** WCS, CAN
Concept Author: G. Kittel, C. Chappel, R. Crawford **LeadResp:** WCS

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APPENDIX D: GLO MAPS FOR 18 TREE AND SHRUB SPECIES

As described in appendix B, tree species occurring at section corners or quarter-corners were analyzed individually (by species) during cokriging and maximum entropy phases of a GLO map preparation process.

This process generated maps for 18 individual tree and shrub species; these species maps are available from a GLO section of the Forest's history website (but only as color PDF files in 8½" × 11" format). No GIS format is available for tree species maps from the GLO website. GIS data, however, is available for species in a raster (grid) format; contact the Umatilla NF's vegetation analyst for access to that information).

This appendix provides image files derived from GIS presentation maps (PDF format) as they were prepared for the Forest's history website:
https://www.fs.usda.gov/detail/umatilla/learning/history-culture/?cid=stelprdb5210179

On a GLO website, and in this appendix, image files are provided for 18 species:

Birch

Black cottonwood

Cherry

Douglas-fir

Engelmann spruce

Grand fir

Lodgepole pine

Mountain alder

Mountain hemlock

Mountain mahogany

Ponderosa pine

Quaking aspen

Rocky Mountain maple

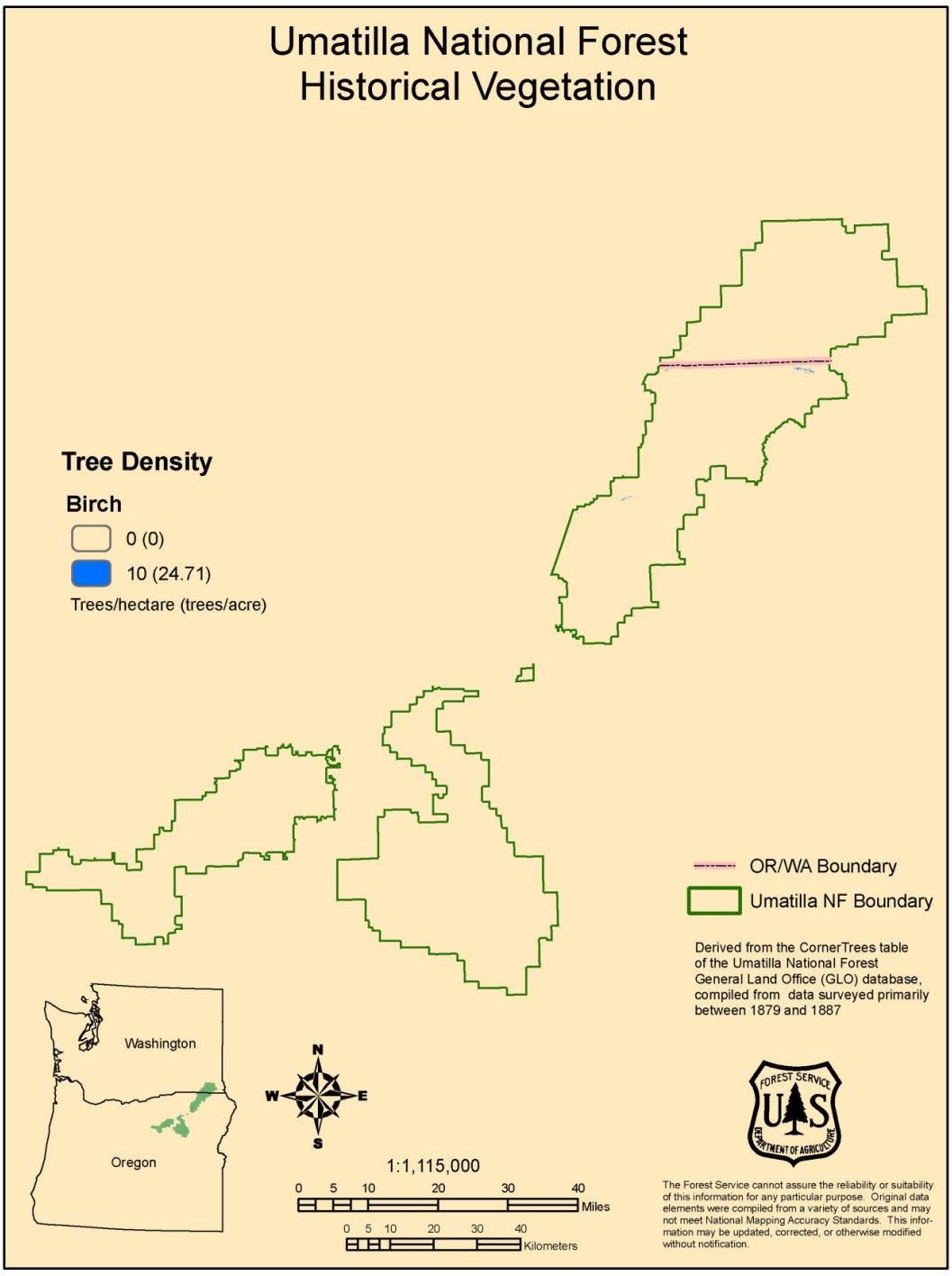
Subalpine fir

Western juniper

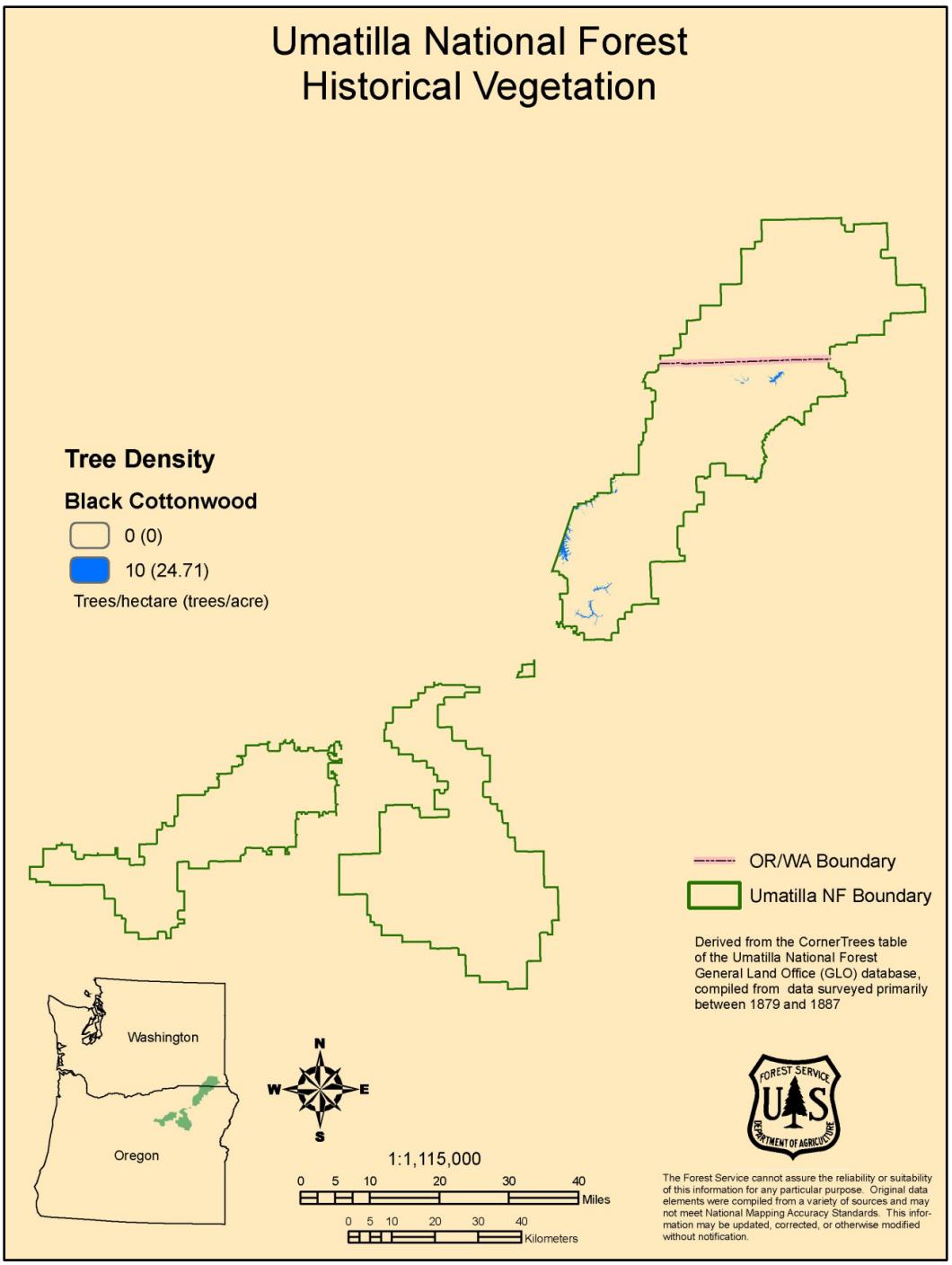
Western larch

Willow

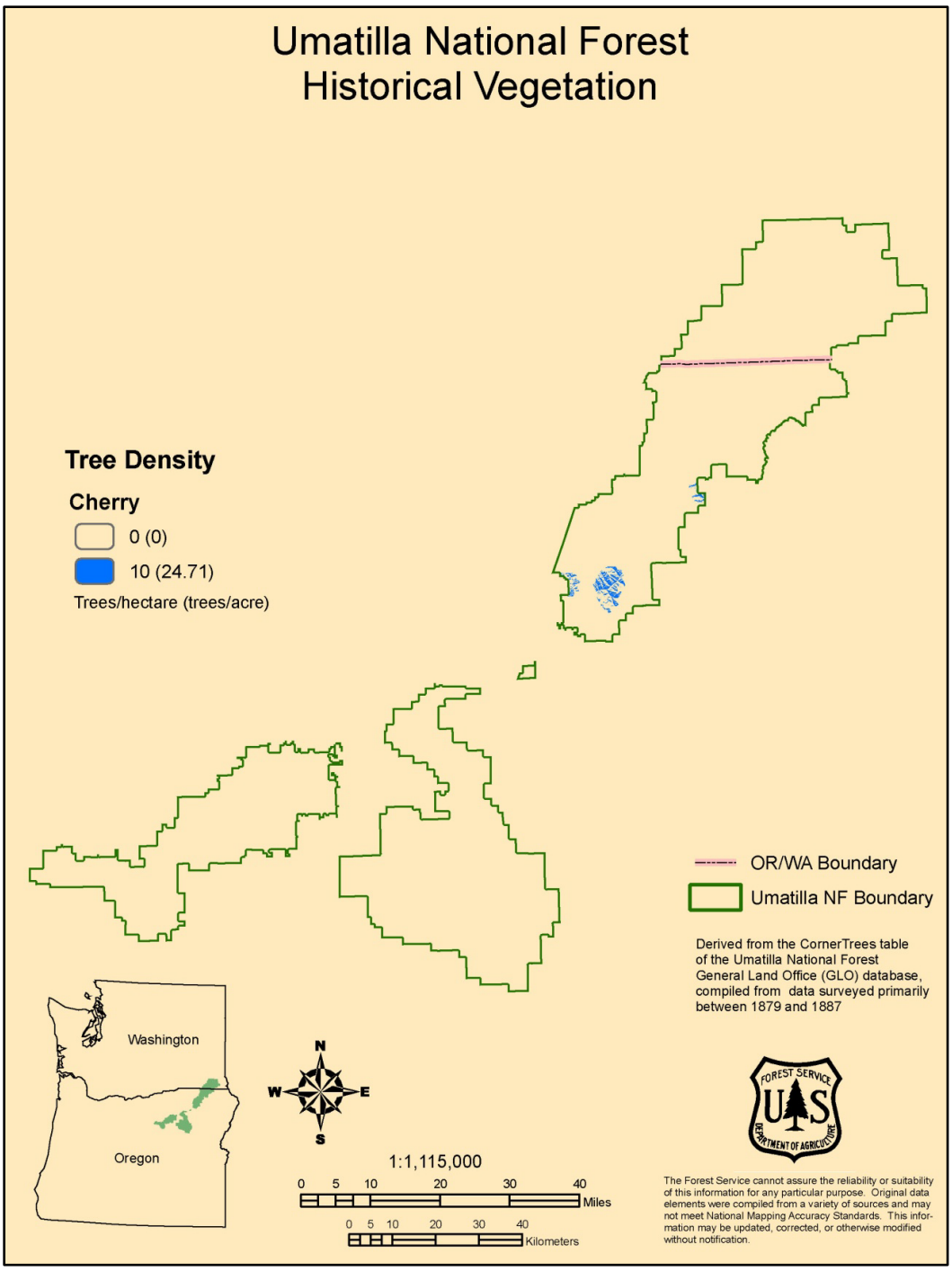
Yew



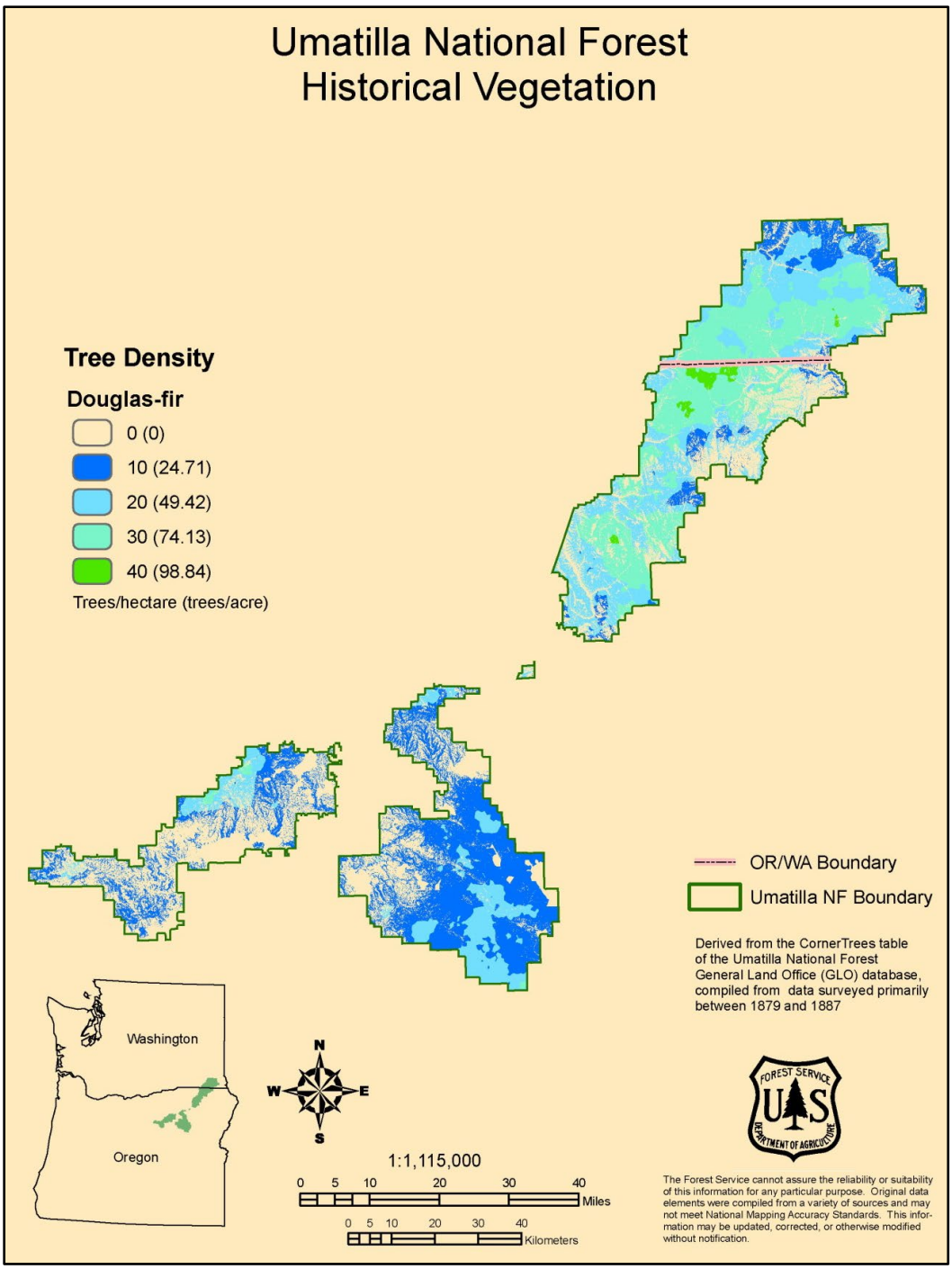
Interpolated tree density for birch



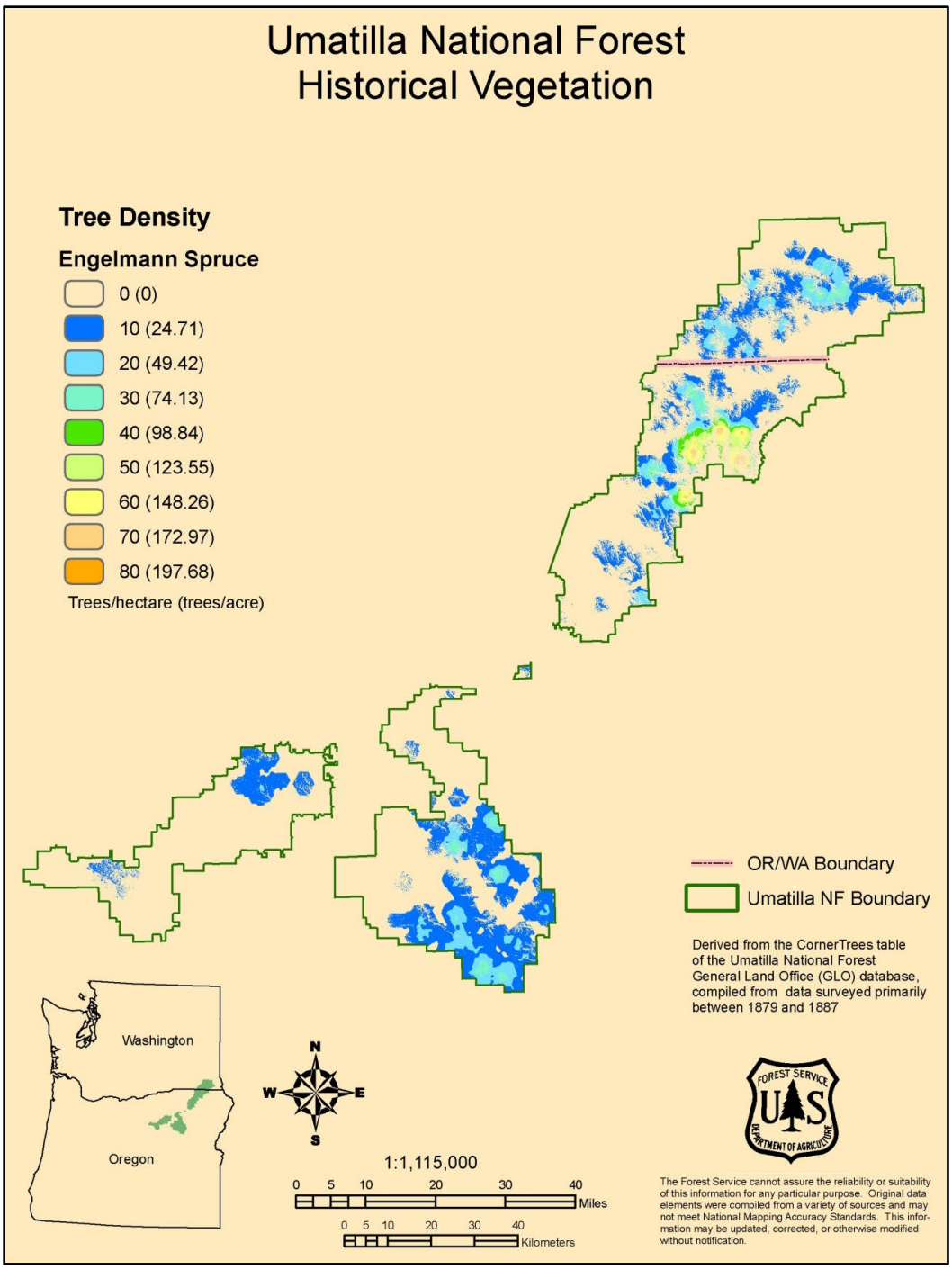
Interpolated tree density for black cottonwood



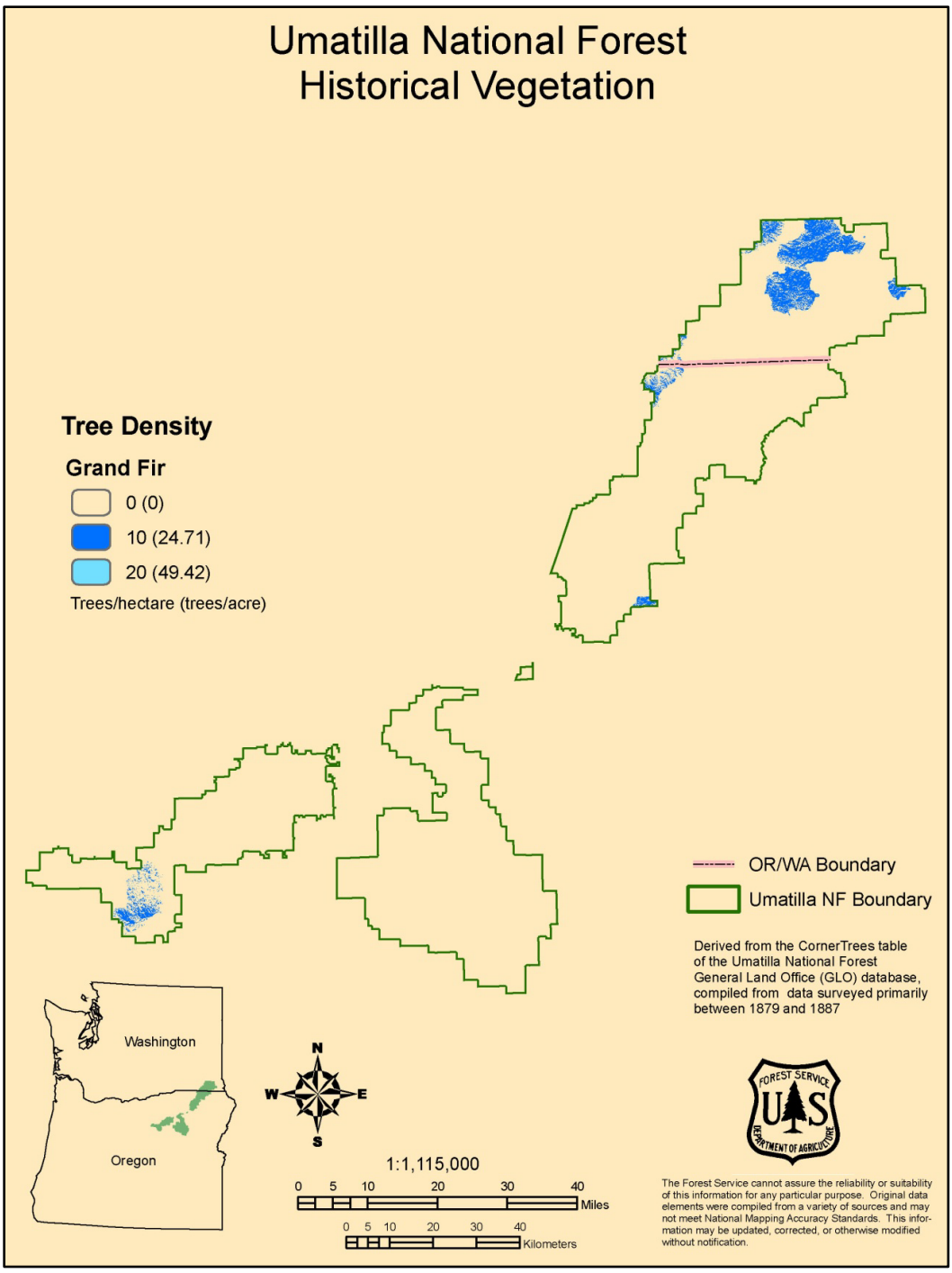
Interpolated tree density for cherry



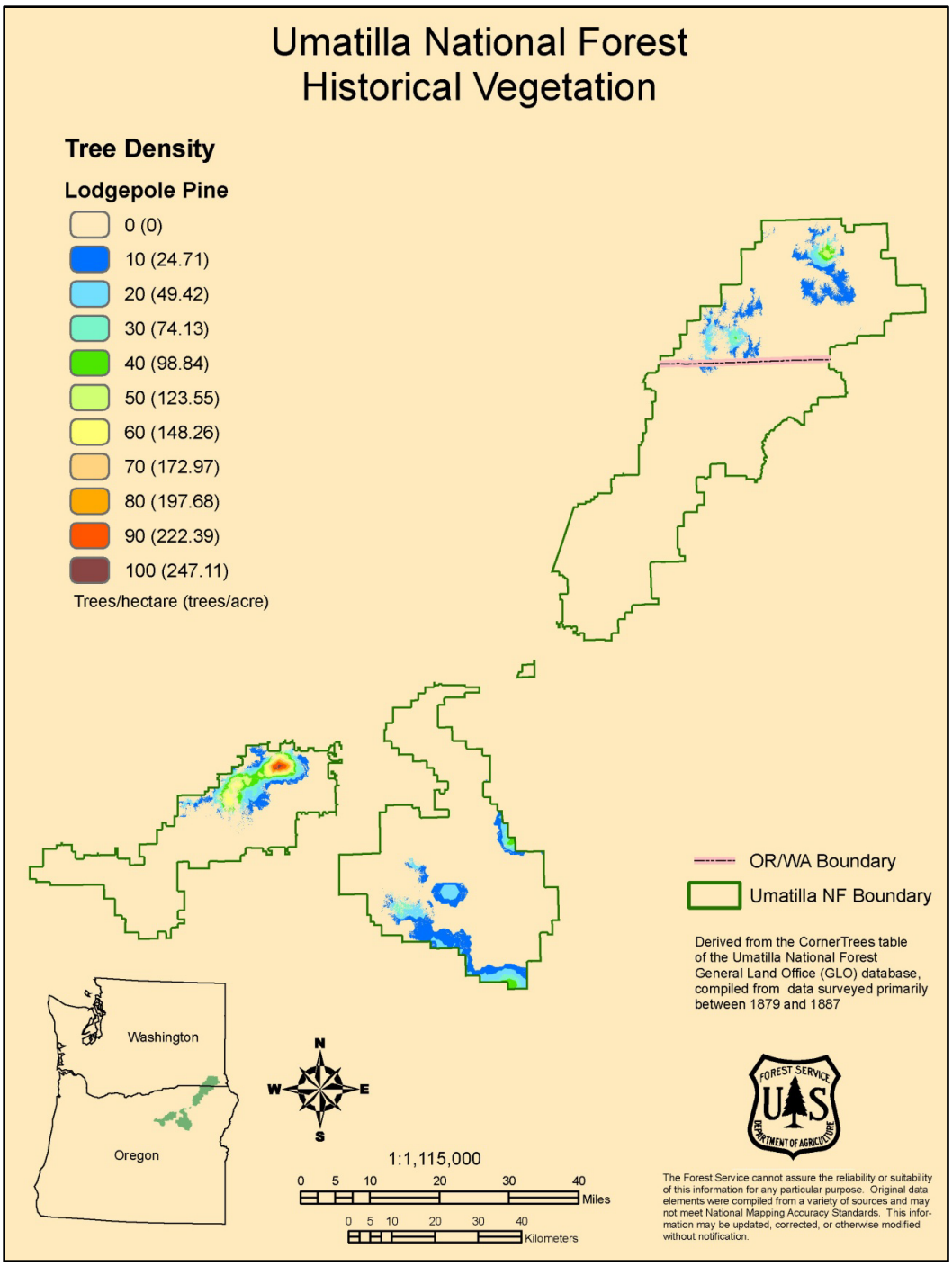
Interpolated tree density for Douglas-fir



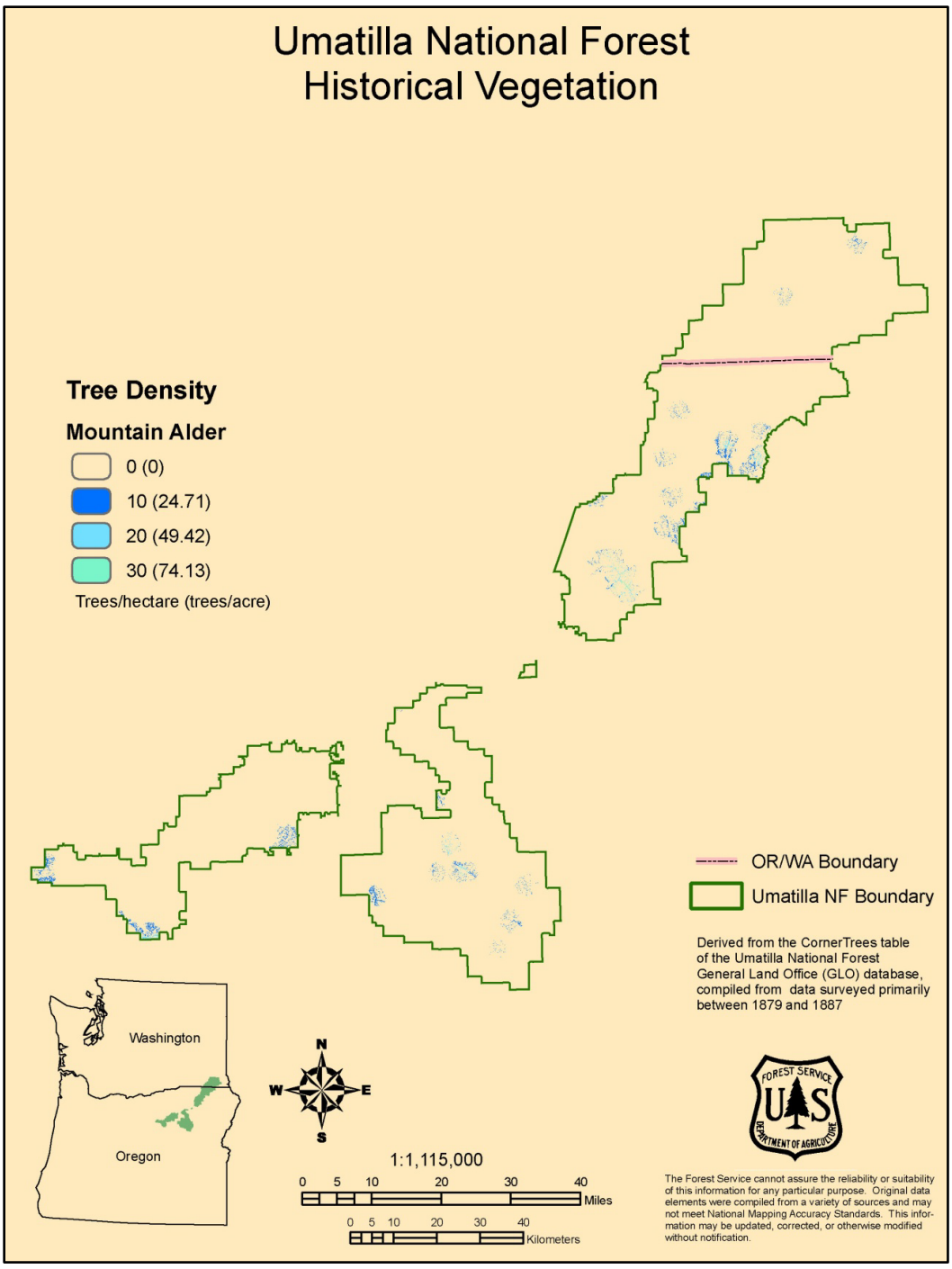
Interpolated tree density for Engelmann spruce



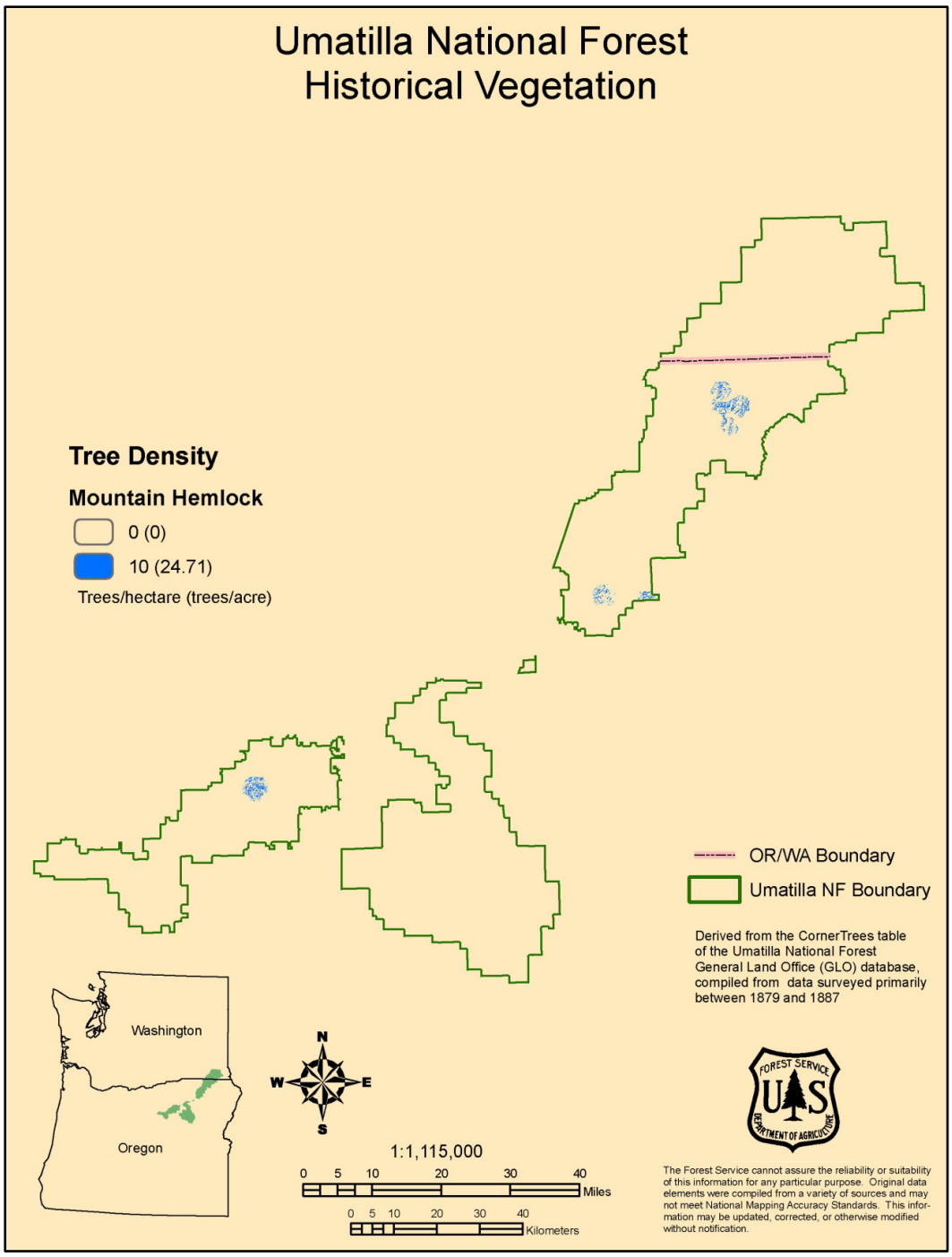
Interpolated tree density for grand fir



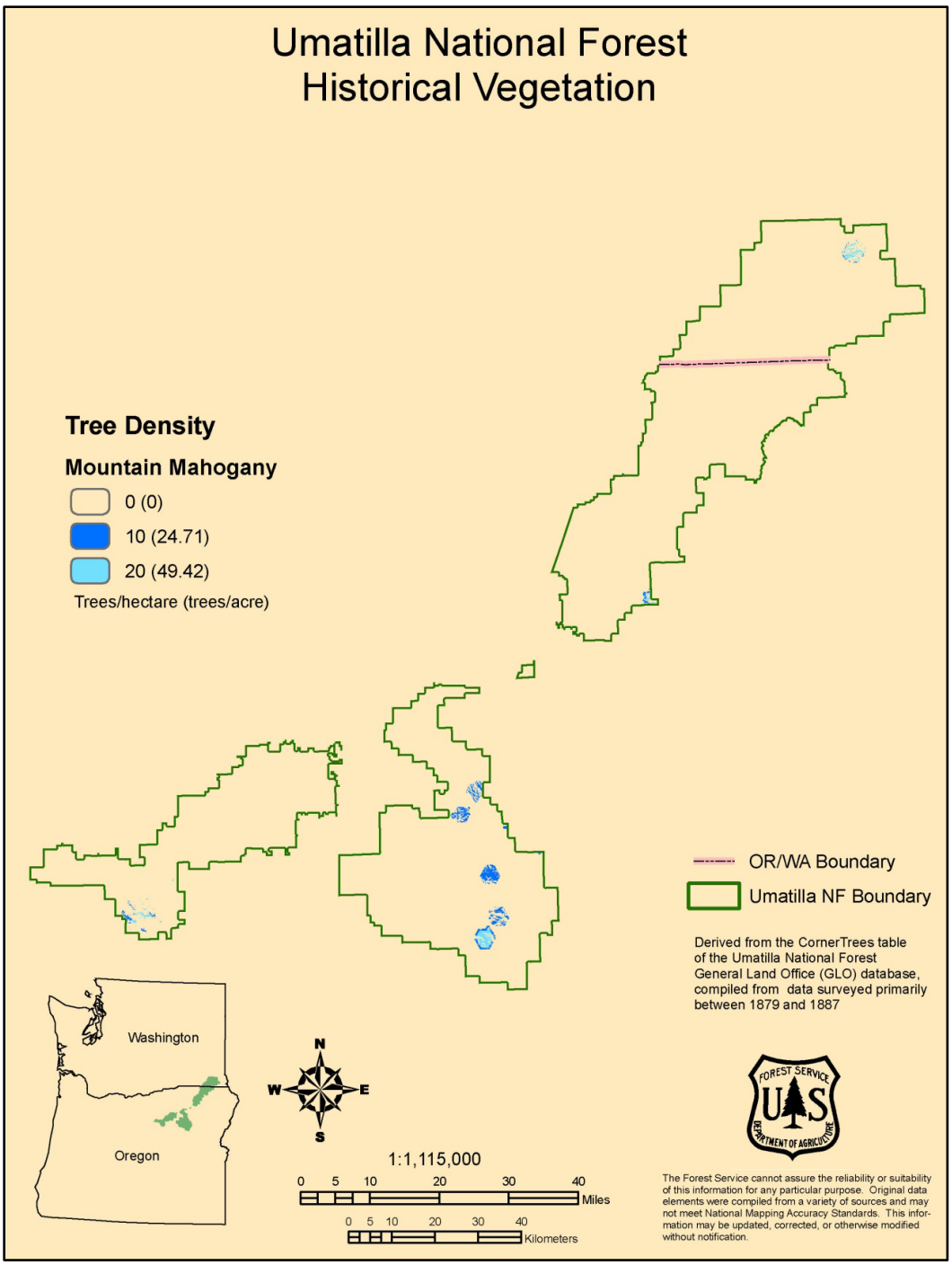
Interpolated tree density for lodgepole pine



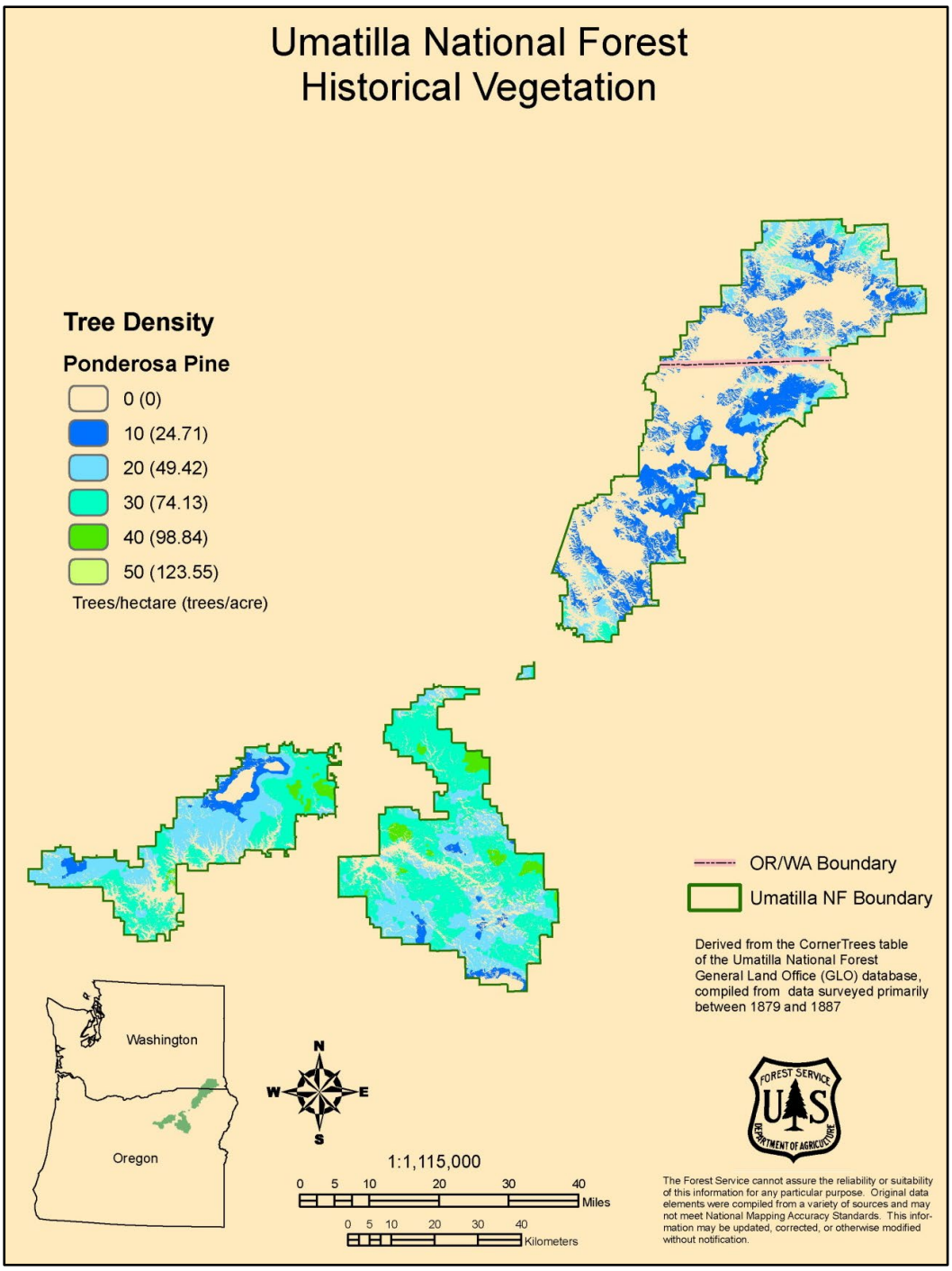
Interpolated tree density for mountain alder



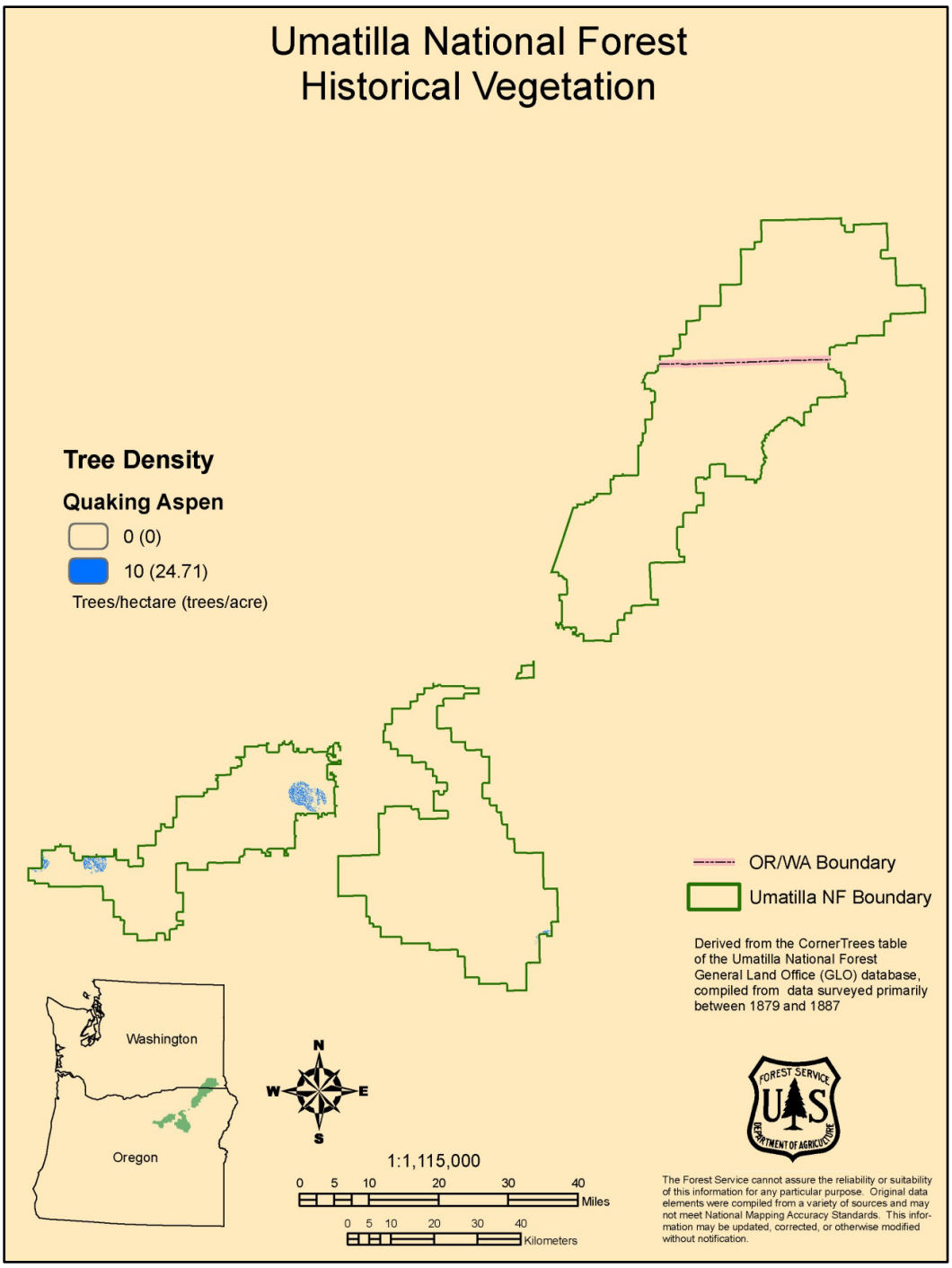
Interpolated tree density for mountain hemlock



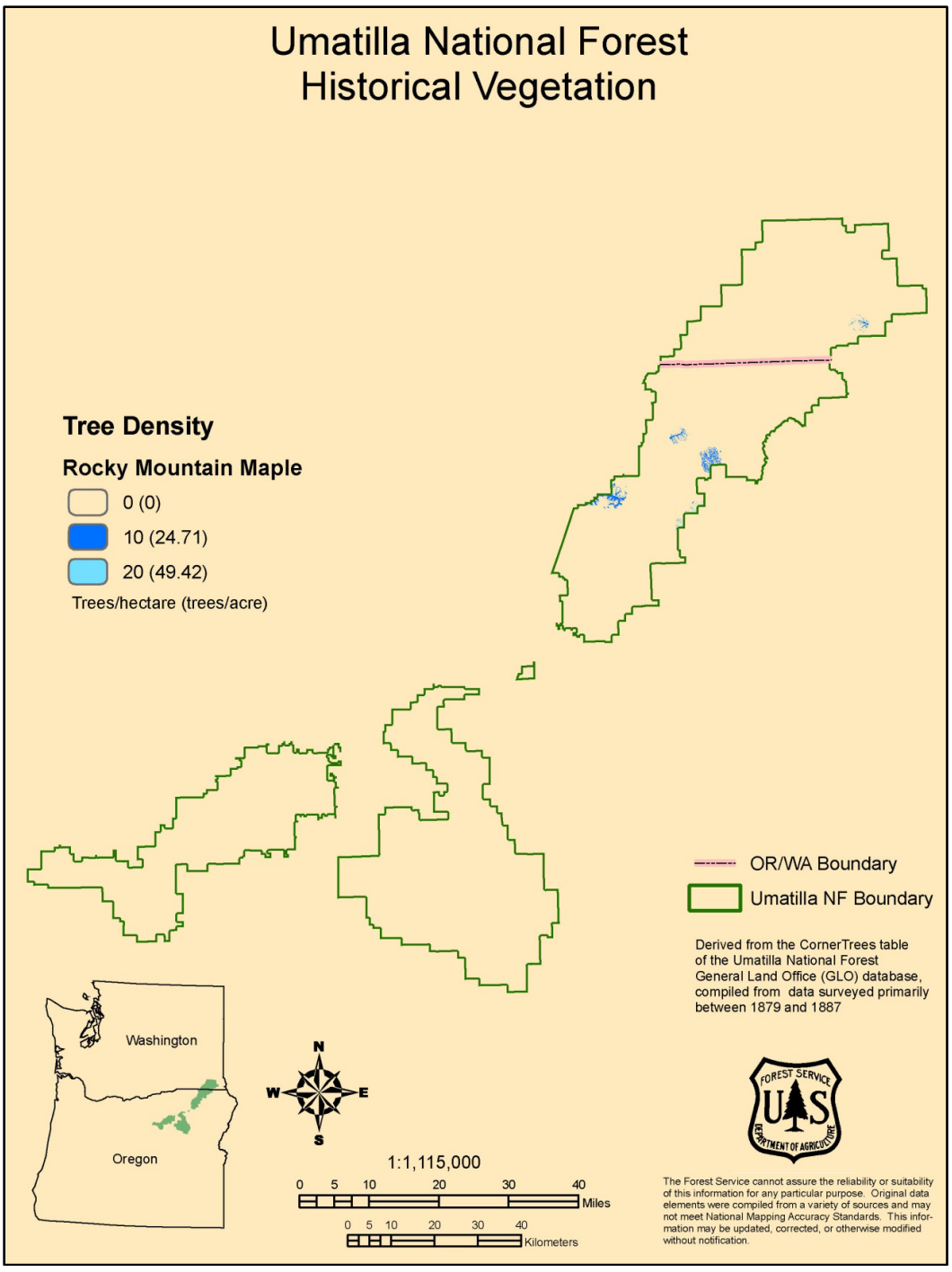
Interpolated tree density for mountain mahogany



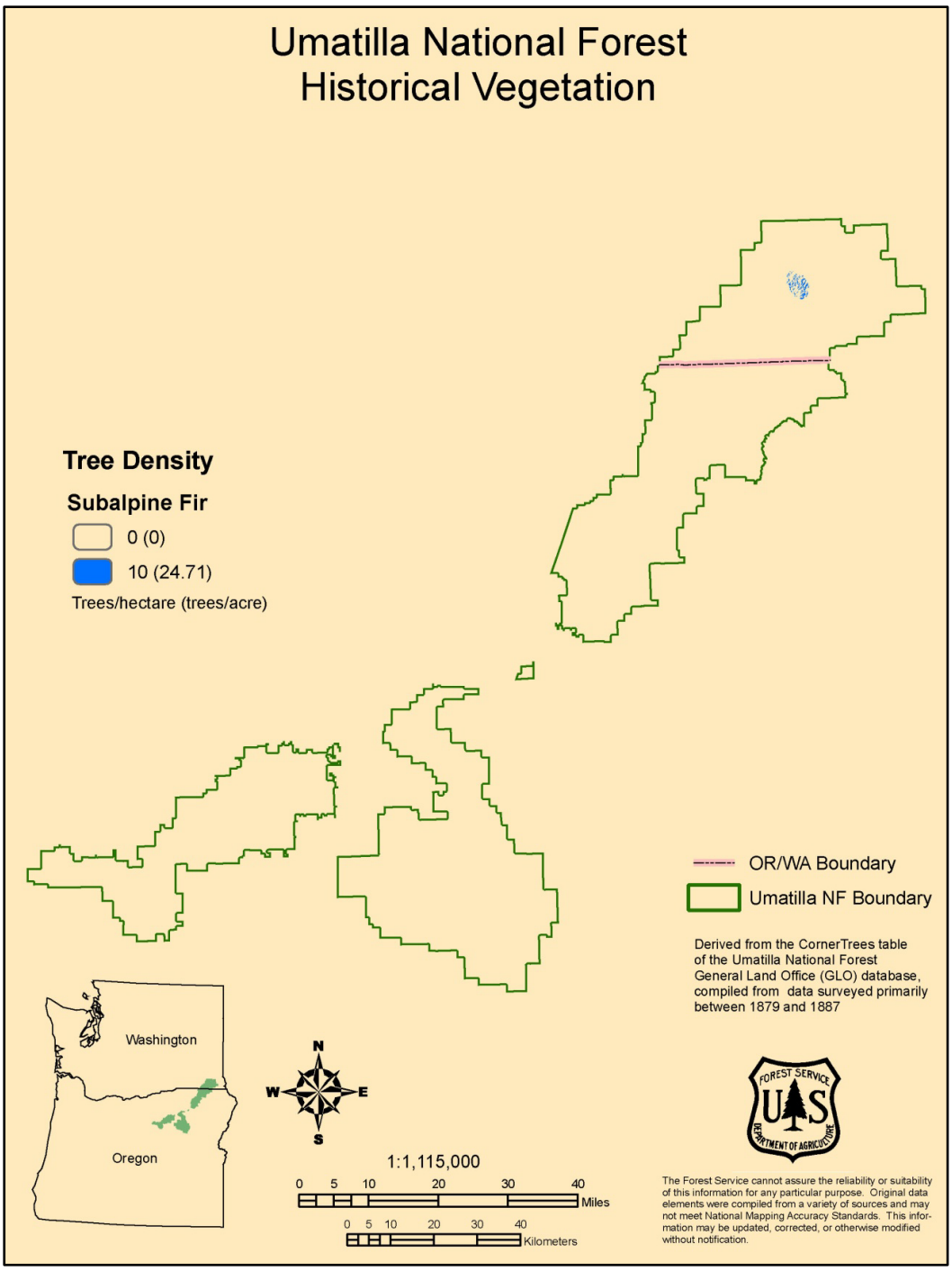
Interpolated tree density for ponderosa pine



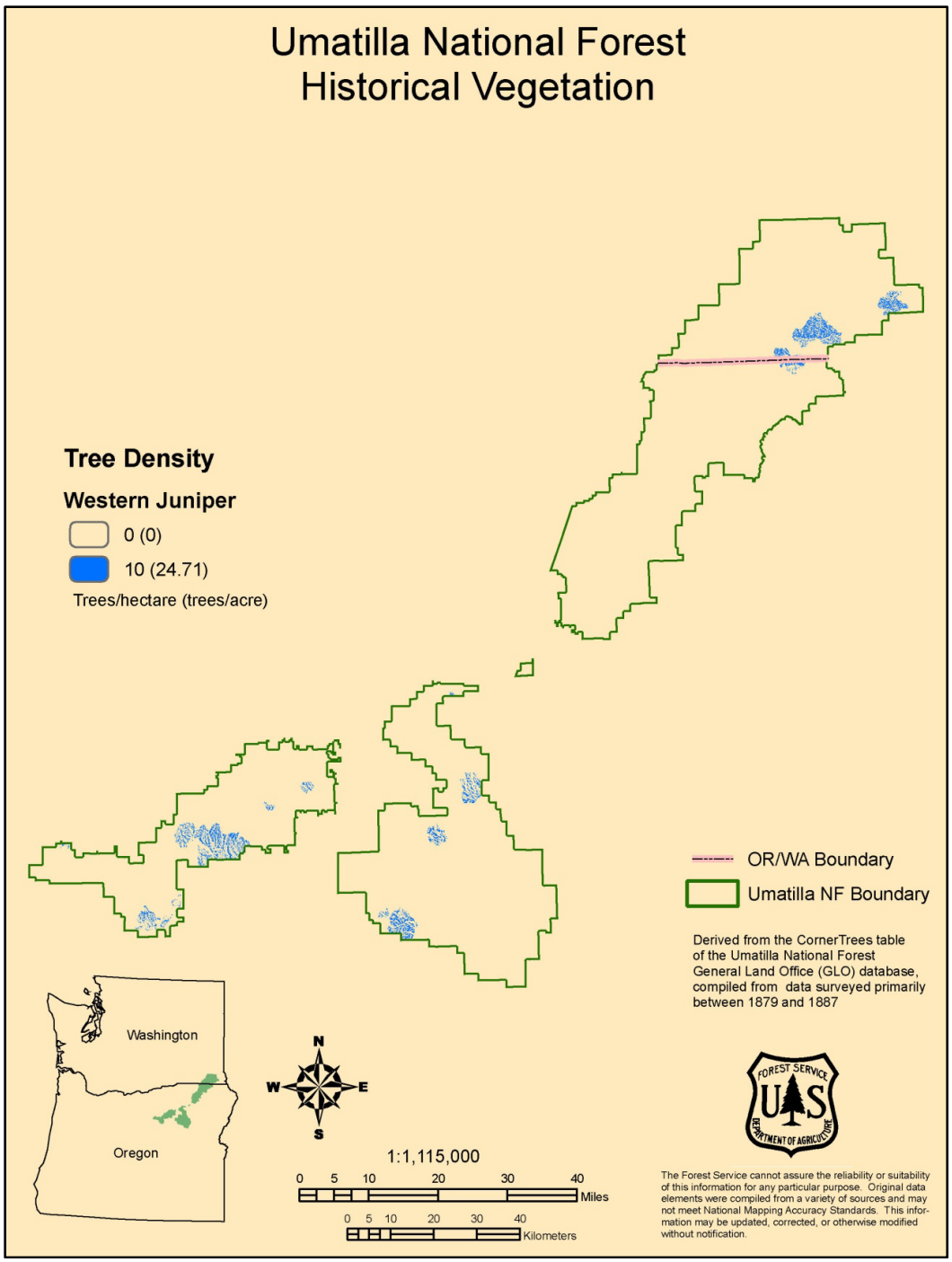
Interpolated tree density for quaking aspen



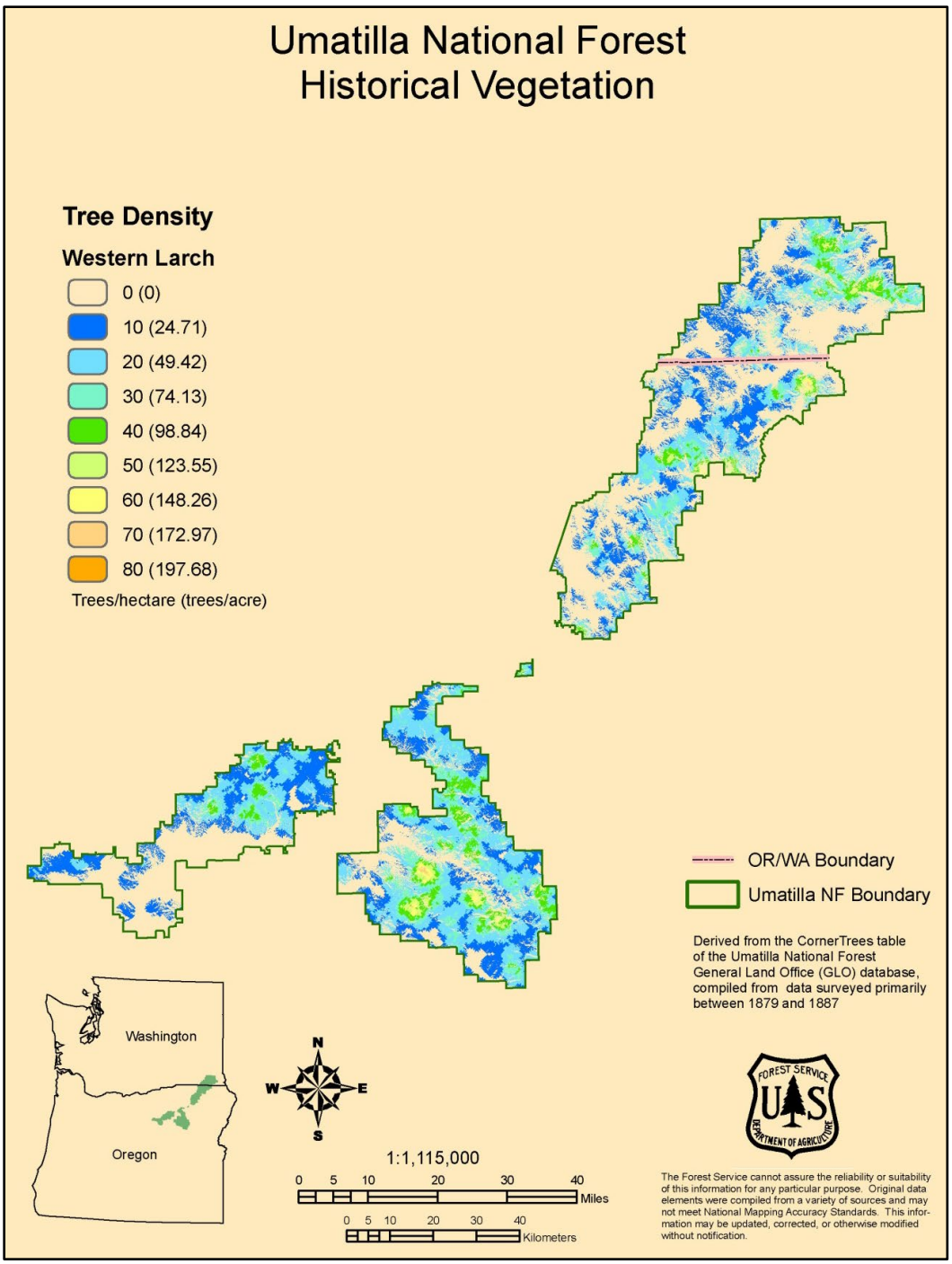
Interpolated tree density for Rocky Mountain maple



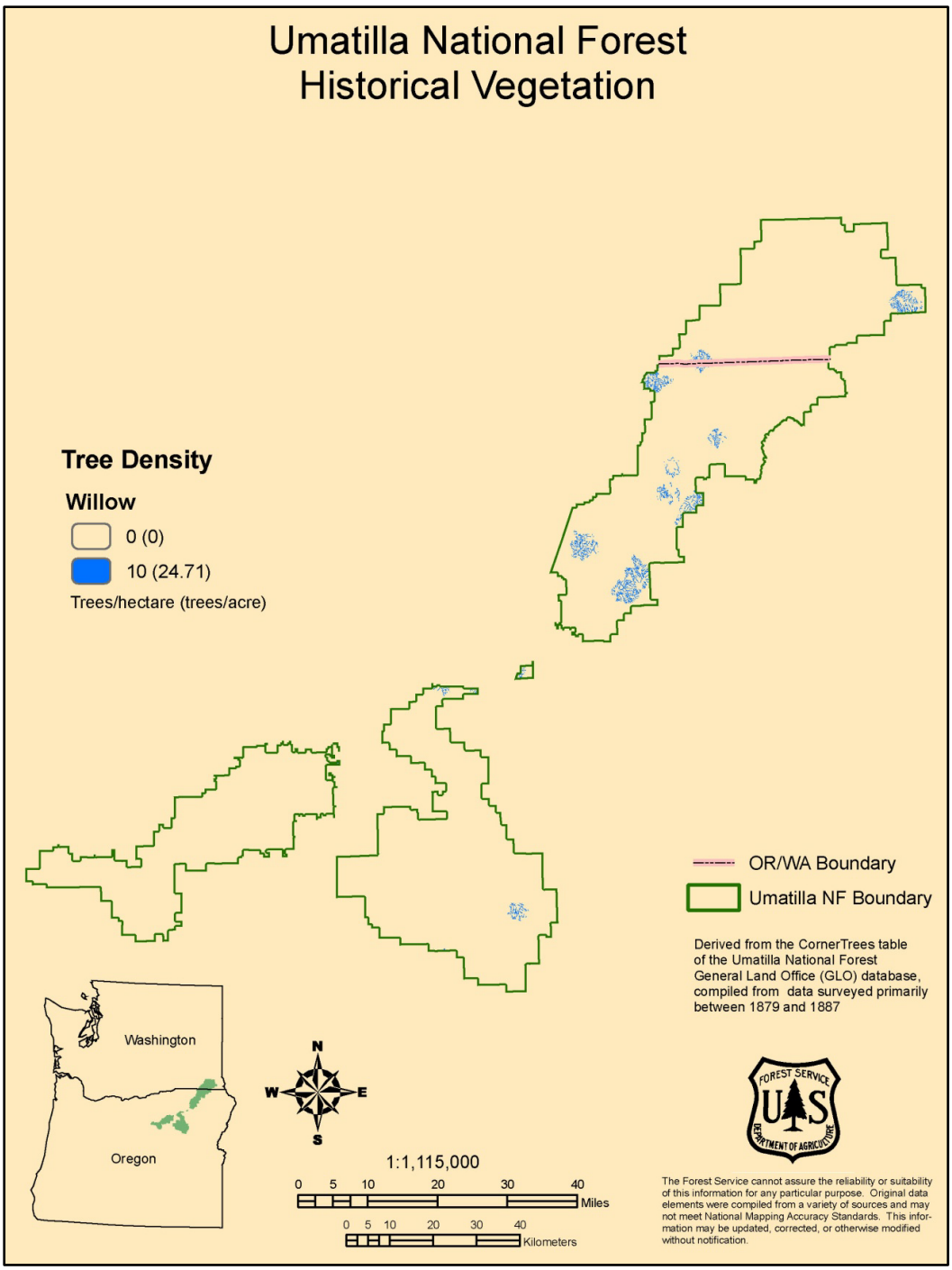
Interpolated tree density for subalpine fir



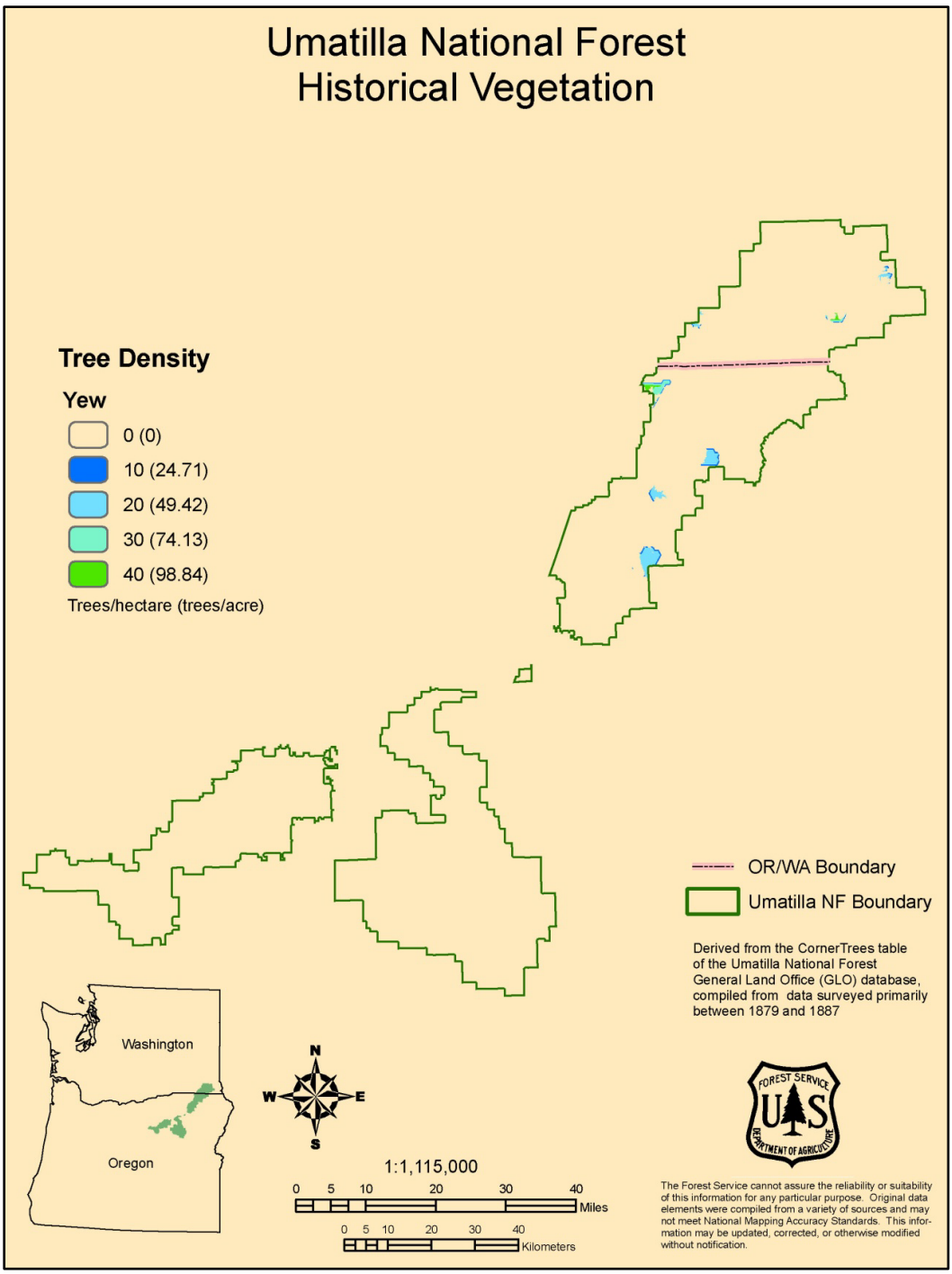
Interpolated tree density for western juniper



Interpolated tree density for western larch



Interpolated tree density for willow



Interpolated tree density for yew

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APPENDIX E: SILVICULTURE WHITE PAPERS

White papers are internal reports, and they are produced with a consistent formatting and numbering scheme – all papers dealing with Silviculture, for example, are placed in a silviculture series (Silv) and numbered sequentially. Generally, white papers receive only limited review and, in some instances pertaining to highly technical or narrowly focused topics, the papers may receive no technical peer review at all. For papers that receive no review, the viewpoints and perspectives expressed in the paper are those of the author only, and do not necessarily represent agency positions of the Umatilla National Forest or the USDA Forest Service.

Large or important papers, such as two papers discussing active management considerations for dry and moist forests (white papers Silv-4 and Silv-7, respectively), receive extensive review comparable to what would occur for a research station general technical report (but they don't receive blind peer review, a process often used for journal articles).

White papers are designed to address a variety of objectives:

(1) They guide how a methodology, model, or procedure is used by practitioners on the Umatilla National Forest (to ensure consistency from one unit, or project, to another).
(2) Papers are often prepared to address ongoing and recurring needs; some papers have existed for more than 20 years and still receive high use, indicating that the need (or issue) has long standing – an example is white paper #1 describing the Forest's big-tree program, which has operated continuously for 25 years.
(3) Papers are sometimes prepared to address emerging or controversial issues, such as management of moist forests, elk thermal cover, or aspen forest in the Blue Mountains. These papers help establish a foundation of relevant literature, concepts, and principles that continuously evolve as an issue matures, and hence they may experience many iterations through time. [But also note that some papers have not changed since their initial development, in which case they reflect historical concepts or procedures.]
(4) Papers synthesize science viewed as particularly relevant to geographical and management contexts for the Umatilla National Forest. This is considered to be the Forest's self-selected 'best available science' (BAS), realizing that non-agency commenters would generally have a different conception of what constitutes BAS – like beauty, BAS is in the eye of the beholder.
(5) The objective of some papers is to locate and summarize the science germane to a particular topic or issue, including obscure sources such as master's theses or Ph.D. dissertations. In other instances, a paper may be designed to wade through an overwhelming amount of published science (dry-forest management), and then synthesize sources viewed as being most relevant to a local context.
(6) White papers function as a citable literature source for methodologies, models, and procedures used during environmental analysis – by citing a white paper,

specialist reports can include less verbiage describing analytical databases, techniques, and so forth, some of which change little (if at all) from one planning effort to another.

(7) White papers are often used to describe how a map, database, or other product was developed. In this situation, the white paper functions as a 'user's guide' for the new product. Examples include papers dealing with historical products: (a) historical fire extents for the Tucannon watershed (WP Silv-21); (b) an 1880s map developed from General Land Office survey notes (WP Silv-41); and (c) a description of historical mapping sources (24 separate items) available from the Forest's history website (WP Silv-23).

The following papers are available from the Forest's website: Silviculture White Papers

Paper #	Title
1	Big tree program
2	Description of composite vegetation database
3	Range of variation recommendations for dry, moist, and cold forests
4	Active management of Blue Mountains dry forests: silvicultural considerations
5	Site productivity estimates for upland forest plant associations of Blue and Ochoco Mountains
6	Blue Mountains fire regimes
7	Active management of Blue Mountains moist forests: silvicultural considerations
8	Keys for identifying forest series and plant associations of Blue and Ochoco Mountains
9	Is elk thermal cover ecologically sustainable?
10	A stage is a stage is a stage…or is it? Successional stages, structural stages, seral stages
11	Blue Mountains vegetation chronology
12	Calculated values of basal area and board-foot timber volume for existing (known) values of canopy cover
13	Created opening, minimum stocking, and reforestation standards from Umatilla National Forest Land and Resource Management Plan
14	Description of EVG-PI database
15	Determining green-tree replacements for snags: a process paper
16	Douglas-fir tussock moth: a briefing paper
17	Fact sheet: Forest Service trust funds
18	Fire regime condition class queries
19	Forest health notes for an Interior Columbia Basin Ecosystem Management Project field trip on July 30, 1998 (handout)
20	Height-diameter equations for tree species of Blue and Wallowa Mountains
21	Historical fires in headwaters portion of Tucannon River watershed
22	Range of variation recommendations for insect and disease susceptibility
23	Historical vegetation mapping
24	How to measure a big tree
25	Important Blue Mountains insects and diseases

Paper #	Title
26	Is this stand overstocked? An environmental education activity
27	Mechanized timber harvest: some ecosystem management considerations
28	Common plants of south-central Blue Mountains (Malheur National Forest)
29	Potential natural vegetation of Umatilla National Forest
30	Potential vegetation mapping chronology
31	Probability of tree mortality as related to fire-caused crown scorch
32	Review of “Integrated scientific assessment for ecosystem management in the interior Columbia basin, and portions of the Klamath and Great basins” – forest vegetation
33	Silviculture facts
34	Silvicultural activities: description and terminology
35	Site potential tree height estimates for Pomeroy and Walla Walla Ranger Districts
36	Stand density protocol for mid-scale assessments
37	Stand density thresholds related to crown-fire susceptibility
38	Umatilla National Forest Land and Resource Management Plan: forestry direction
39	Updates of maximum stand density index and site index for Blue Mountains variant of Forest Vegetation Simulator
40	Competing vegetation analysis for southern portion of Tower Fire area
41	Using General Land Office survey notes to characterize historical vegetation conditions for Umatilla National Forest
42	Life history traits for common Blue Mountains conifer trees
43	Timber volume reductions associated with green-tree snag replacements
44	Density management field exercise
45	Climate change and carbon sequestration: vegetation management considerations
46	Knutson-Vandenberg (K-V) program
47	Active management of quaking aspen plant communities in northern Blue Mountains: regeneration ecology and silvicultural considerations
48	Tower Fire…then and now. Using camera points to monitor postfire recovery
49	How to prepare a silvicultural prescription for uneven-aged management
50	Stand density conditions for Umatilla National Forest: a range of variation analysis
51	Restoration opportunities for Umatilla National Forest: upland forest biophysical environments
52	New perspectives in riparian management: Why might we want to consider active management for certain portions of riparian habitat conservation areas?
53	Eastside Screens chronology
54	Using mathematics in forestry: an environmental education activity
55	Silviculture certification: tips, tools, and trip-ups
56	Vegetation polygon mapping and classification standards: Malheur, Umatilla, and Wallowa-Whitman National Forests

Paper #	Title
57	State of vegetation databases for Malheur, Umatilla, and Wallowa-Whitman National Forests
58	Seral status for tree species of Blue and Ochoco Mountains

REVISION HISTORY

February 2013: minor formatting and editing changes were made; appendix E was added describing the white paper system, including a list of available white papers.

November 2019: minor formatting changes were made throughout the document; since the document had grown to more than 100 pages in length, a Contents section was added.