Ponderosa Pine Forest Management
and
Silvicultural Prescription Guidelines

INSTITUTE OF AGRICULTURE AND NATURAL RESOURCES

NEBRASKA FOREST SERVICE University of Nebraska-Lincoln

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Contents

Nebraska Forest Management Guidelines

Nebraska's Forest Management Guidelines incorporate an understanding of natural disturbance and stand development processes most commonly described as ecological forestry. Ecological Forestry seeks to emulate, to the extent possible, natural forest development, including the role of natural disturbances (fire, ungulates, etc…) in the initiation, development, and maintenance of stands and landscapes. There may never be a single definition of ecological forestry, but most definitions share some central themes. Seven elements that are consistent across definitions of ecological forestry (and perhaps all good forestry) are:

1) Forests have intrinsic value,
2) Humans need to extract products from the forest,
3) Silviculture should follow natural processes as much as possible,
4) Foresters should plan for the long term,
5) Forestry is implemented at the stand scale but must be in balance with the larger ecosystem,
6) The social and economic context matters, and
7) Science and place-based experience should guide silviculture.

By emulating natural processes Ecological Forestry should maintain (or even restore) natural forest patterns and structures (Evans, 2006)

Despite science's best efforts forest management remains an art in its application, informed by science. Therefore, it is expected that Nebraska Forest Service Foresters will use their experience and imagination to apply these guidelines to meet each landowner's individual goals in the context and the limitations of the land.

Overview

Ponderosa pine is an important forest species in the Niobrara Valley, Pine Ridge, and Wildcat Hills of Nebraska. It occurs in almost pure stands with no real associates. Ponderosa pine woodlands (open stands of trees and mixed-grass prairie, generally forming 25-60% cover) often occupy south- and west-facing slopes. While denser pine forests (trees with crowns overlapping, forming 60-100% cover) occupy north- and east-facing slopes and bottoms.

Ponderosa pine is adapted to fire which reduces or removes competing vegetation and helps to maintain it as a monoculture on the landscape. While this may give ponderosa pine Forests and Woodlands an uneven-aged appearance they are, in reality, a mosaic of even-aged groups.

Seedlings are relatively shade intolerant and require canopy-opening disturbances such as fire, logging, or tree death to establish. Once seed becomes established Ponderosa pine grows a vigorous taproot. This adaptation is one reason for their tenacity on severe sites. It is very drought tolerant. Once established it can survive hot and dry conditions and withstand very cold winters.

Ponderosa Pine grows on a wide variety of soils however it does not grow well on alkaline soils, preferring soils with a pH of 6.0 to 7.0. It does not tolerate high water table or wetlands.

Biomass allocation shifts as trees mature. As seedlings, ponderosa pine allocates relatively more biomass to roots compared to stems and leaves.

Saplings tend to allocate relatively more of their biomass to foliage, and pole-sized trees allocate more biomass to woody tissue. As these stands mature and trees compete for site resources lower branches self-prune and trees lose vigor. However, it remains physiologically young and responds well to thinning.

Ponderosa pine forest supports many at-risk species at the edge of their range including Rocky Mountain bighorn sheep (Ovis canadensis canadensis).

Drought, fire suppression, encroachment of eastern redcedar in the understory and a lack of grazing have contributed to catastrophic wildfires in 2006 and 2012 that has led to a significant loss of pine forests and woodlands and created an impetus to manage these lands for greater spatial heterogeneity and age-class diversity.

Uses

Erosion control:

Ponderosa pine is a rapid growing tree with the ability to firmly anchor into most soil types. For this reason, it is suitable for use as a windbreak species.

Livestock:

The young tree itself is not eaten by livestock unless most of the other browse species have been destroyed by overgrazing. When eaten by cows during gestation this species may cause abortion.

Wildlife:

While deer, elk and mountain sheep do not eat the needles unless other browse species are totally absent, they do feed on the understory species. The seeds of ponderosa pine are choice food of red-winged blackbirds, chickadees, mourning doves, finches, evening grosbeaks, jays, Clark's nutcrackers, nuthatches, white-throated sparrows, rufous-sided towhees, turkeys, chipmunks and squirrels. The pine needles are important food of blue and spruce grouses. The pine bark is fair food for beavers, and is used by porcupines which sometimes damage the trees. Cavity-nesting bats, squirrels, and birds, such as nuthatches, woodpeckers, and wrens, will create nest holes or make use of existing cavities in dead ponderosa pines.

Wood production:

Ponderosa pine is one of the most important timber species in the western United States It makes excellent lumber for cabinet and construction work. Although Ponderosa Pine is technically classified as a yellow (hard) pine, it shares many characteristics with white (soft) pines, having a considerably lower density than the yellow pine species found in the eastern United States.

Markets:

The forest products industry in Nebraska has declined. The two most prominent reasons are the loss of markets for roundwood and pulp as mills have gone out of business and transportation costs have made it too expensive to transport Nebraska's ponderosa pine to those mills still operating.

There are limited markets for biomass, most notably Chadron State College in the Pine Ridge, and there may be some potential to develop carbon markets.

Silvical Characteristics

Ponderosa pine occurs as a mosaic across the landscape with varying density, age-classes and structure, sometimes within a single stand. This is primarily the result of the disturbance regimes that affect regeneration, mortality, stand density, and other ecosystem processes. Fire is the primary disturbance agent, but insects, wind, and pathogens are also important. Although fire regimes are highly variable across the entire range of ponderosa pine, a low severity, high frequency regime is common in most areas with pure pine. The result, prior to European settlement, was an abundance of unmanaged stands with multiple age classes of trees (O'Hara, 2005)

Habitat:

Ponderosa pine trees occur as pure stands in Nebraska. Ponderosa pine forests become mixed pine and hardwood forests in low-lying riparian areas with green ash, elm and cottonwood as common associates. Eastern redcedar has become established in the understory in most areas of the state dominating the understory and creating deep shade which greatly diminishes pine regeneration. Eastern redcedar has also become a ladder fuel in these stands creating enhanced risks for severe crown fires.

Drought Tolerance

Ponderosa pine is very drought tolerant. Once established it also survives hot and dry conditions, exhibiting medium to good drought tolerance and can withstand very cold winters.

Soils

The plant is found on a wide variety of soils from shallow to deep, and from gravely or cobbly sands to sandy clay loam and loams in texture, but mostly on sandy loams. It does not grow well on alkaline soils, preferring soils with a pH of 6.0 to 7.0, and it does not grow well where the water table is near the surface.

Rooting Habit

The ability of ponderosa pine seedlings to grow vigorous taproots is one reason for their tenacity on severe sites where associated species often fail. Within a few months of germination, roots can penetrate to depths of 20 inches. This rapid root growth is essential to ponderosa pine's apparent adaptation to dry and arid sites

Reaction to Competition

Because of ponderosa pine's intolerance of shade, it tends to grow in even-aged stands and is usually managed by that method. Uneven-aged stands might appear common throughout the drier portion of its range but are, in reality, a mosaic of even-aged groups. Ponderosa pines lose vigor in dense stands.

It responds well to thinning, which should be done as stands become older to develop larger crowns, resulting in heavier seed crops for wildlife.

Response to thinning

As ponderosa pine matures it allocates biomass to height growth once it reaches sapling size. As stands become denser it will allocate biomass to diameter growth. Ponderosa pine remains physiologically young and responds well to thinning. Stagnated trees usually respond to thinning and seem to grow as rapidly as unstagnated trees, where crowns grow to sufficient size to take advantage of the additional growing space.

Silvopasture

Silvopasture combines trees with forage and livestock production. The trees are managed for high-value sawlogs and, at the same time, provide shade and shelter for livestock and forage, reducing stress and sometimes increasing forage production.

Young stands should be protected from over-grazing by livestock when green feed is limited. Use of tree foliage by livestock usually indicates excessive overuse of the associated plants. Grazing herbs, grasses and forbs by livestock will cause little to no damage to young or old trees when properly implemented. Proper spacing of trees will provide more feed for livestock as well as greater timber production.

Fire

Ponderosa pine is resistant to fire due to its thick bark. Low intensity surface fires control competitive species like scrub oak and shade-tolerant conifers. Ponderosa pine seedlings can also survive low intensity burns.

Management

Goals:

1. Restore tree density in Ponderosa Pine Forests and Woodlands
2. Restore “patchy” tree spatial pattern on the landscape
3. Maintain a wide range of age classes to the greatest extent possible
4. Maintain forest health by selecting healthy, vigorous leave (crop) trees.

Establishment

Seedlings are relatively shade intolerant and require canopy-opening disturbances such as fire, logging, or tree death to establish. Successful natural regeneration is thought to be the result of the chance combination of a heavy seed crop and favorable weather during the next growing season. Soil texture, plant competition, and seedbed conditions are other common determinants of survival of young seedlings.

Chemical and / or mechanical site preparation is necessary control competition. The significance of competing vegetation as a deterrent to early survival and development of young seedlings has been clearly demonstrated. As the tree matures moderate to heavy shade reduces the growth rate significantly.

Reforestation

Seed: Seeds are sown in late March to early April. Enough seed should be used to achieve an initial density of 22 seedlings/ft^2. Seeds do not germinate until the soil is continuously warm and moist.

Seedlings: To ensure initial survival it is recommended that you use containerized seedlings or transplant stock (1-1, 2-1 or 2-2).

Plant 100 to 200 seedlings per acre depending on site (slope, aspect and elevation).

- Ponderosa pine forests (trees with crowns overlapping, forming 60-100% cover) are mainly found on north- and east-facing slopes and bottoms.

- Ponderosa pine woodlands (open stands of trees, generally forming 25-60% cover) and mixed-grass prairie often occupy the south- and west-facing slopes.

More widely spaced trees will develop larger crowns, resulting in heavier seed crops for wildlife and more forage for deer, elk and mountain sheep.

Initial seedling survival is reduced under moisture stress. Older seedlings can tolerate limited moisture. Competition from other vegetation should be controlled for the first three to six years until the trees become well established.

Silvicultural Systems

Uneven-aged

Uneven-aged silvicultural systems can be an effective tool for creating structural diversity within a stand. Group selection systems and "free selection," a refinement to group selection, described as "*the combination of group and single tree selection systems with reserve trees left in all structural stages,*" is recommended for creating clumpy and irregular stand structure.

Even-aged Management

A three-step shelterwood regeneration method has proven to be the most successful regeneration method in ponderosa pine in the Rocky Mountain Region (US Forest Service Region 2). It provides the best chance for securing natural regeneration but may need supplemental planting and/or site preparation in difficult circumstances.

The first cut, in the three-step method, is usually described as a preparatory cut. The second cut is normally the seed cut and reduces the basal area to approximately 40 square feet of basal area per acre. The best trees are retained to provide seed and shelter. If the preparatory cutting has initiated regeneration, the second cut serves as a removal cut but also establishes additional regeneration. The third cut is a removal cut. Logging damage to the understory is the primary concern in implementing this cut.

1) Silvicultural target is based on even-aged regeneration using a "hybrid" 3-step shelterwood (30 - 90 sq. ft. Basal Area / Acre) in combination with group seed tree selection (3 - 9 trees / group).
   a) Crowns of "Leave trees" in these groups will be no closer than 10' to any other "leave tree".
   b) Crowns may touch within the group, but crown separation (30 - 90') will be maintained between individual groups of trees through the stands.
   c) Groups of understory trees must be at least 30' from the dripline of overstory leave trees.

2) Spacing between trees or groups of trees is determined by slope and aspect (see table below). Spacing is a guide only and must be adjusted to leave the best trees with a stocking level of 30 - 90 square feet of basal area per acre.

Table 1. Stand density recommendations by Percent slope

Percent Slope	Maximum Basal Area per Acre	Maximum Trees per Acre	Minimum Acceptable DBH	Approximate Spacing[1]
0 to 10%	90 ft^2	225	6	25’ by 25’
11 to 20	80 ft^2	150	8	35’ by 35’
21 to 30	70 ft^2	125	8	35’ by 35’
31 to 40	60 ft^2	85	10	50’ by 50’
41 to 50	50 ft^2	70	10	55’ by 55’
Greater than 50	40 ft2	55	10	60’ by 60’

Approximate spacing is minimum distance between groups of trees [crown to crown not stem to stem (bole to bole.)]

3) Minimum allowable spacing between the crowns is 10'. No tree less than 10" DBH will be left closer than the minimum allowable spacing to any other tree.

4) Thinning will cut all age and size classes of ponderosa pine in an effort to develop three or more age classes.

Crop tree selection criteria

The selection of Crop Trees should be based on the following criteria; in order:

1) Good crown vigor
   a) Dominant - Well developed crowns extending above the general level of the forest stand canopy, which are receiving full sunlight from above and partly from the sides.
   b) Co-dominant - Crowns that form the general level of the forest stand canopy and receive full sunlight from above, but comparatively little from the sides; usually with medium-sized crowns more or less crowded on the sides.
   c) Foliage - Healthy, long needles dark green in color with a full crown over 1/3 or more of the tree.

2) Good stem quality
   a) Bole - Relatively straight bole / stem for at least 8'; not bent, broken or severely leaning.
   b) Leader - Single terminal leader with no forked (split) top.
   c) Physical - No physical damage from fire, animals or weather on more than ½ of the circumference of the bole or more than 3' in length of the bole.

3) Insect and Disease Resistance
   a) Disease(s) - No apparent damage such as western gall rust, peridermium canker and stalactiform rust. Symptoms of these diseases include gall formation on the branch or stem, canker on the bole or branch, elongated diamond-shaped canker and associated resinosis on the bole.
   b) Insect(s) - No apparent damage from bark beetles (mountain pine, turpentine, and engraver). Symptoms include small, red to yellowish pitch tubes (less than ¼ inch), boring dust in bark crevices or base of tree, dead tops and groups of dead trees without pitchout tubes.

Seed Tree Retention

1) Viable seed trees must meet crop tree selection criteria as previously defined:
   a) Good crown vigor
   b) Good stem quality
   c) No visible evidence of damage to the stem or crown from fire or insects (post fire).
   d) Trees with totally black (torched) stems and / or brown (scorched) foliage do not qualify.

2) Seed tree groups ("islands" of live trees)
   a) Must contain minimum of three (3) live trees no greater than 50' apart.
   b) Maximum distance between groups shall be no more than 300'.

Reserve Tree Retention

Retain a minimum of at least five percent of the standing trees, individuals or groups, and allow them to develop into large, old trees and complete their natural lifespan.
The trees selected may include large vigorous trees, hard and soft mast producing trees, as well as dead, dying and diseased trees that have or can easily develop cavities.

a) Retain at least three snags per acre
b) Retain at least three cavity trees per acre
c) Retain at least three mast trees per acre

All trees retained should be at least 6” DBH and at least half of the retained trees should be larger than 10” DBH.

Trees that may harbor insects or disease should be removed. Snags determined to be a threat to human safety can be cut and retained on site as coarse woody debris.

Order of Removal

All juniper and ponderosa pine trees to be cut are based on the following characteristics:

1) High risk of mortality or failure (unless retained as a wildlife tree)
   a) Bole - Severely bent, broken or deformed main stems so pronounced that a straight, 8' log cannot be cut from the trees.
   b) Forked - Trees with 2 or more terminal leaders forming split tops.
   c) Physical - Damage on ½ or more of the bole circumference and greater than 3' in length caused by equipment, falling trees, lightning, wind, snow, animals, etc.

2) Low crown vigor
   a) Foliage - Sparse, unhealthy needles that are yellow, reddish and stunted; holes / gaps occupy a crown that is 1 / 3 or less of the entire tree.

b) Suppressed - Crowns below the general level of the forest stand canopy which receive only partial sunlight either from above or from the sides; they include leaning trees as well as trees with lopsided crowns.

3) Dead, Diseased or declining
   a) Dead - Standing trees 9.9" DBH and smaller down to 2' tall with red, brown or no needles in the crown.
   b) Disease - Damage such as western gall rust, peridermium canker and stalactiform rust. Symptoms include gall formation on the branch / stem, canker on the bole / branch, elongated, diamond-shaped canker and associated resinosis on the bole.
   c) Insect - Damage from bark beetles (mountain pine, turpentine, and engraver). Symptoms include red to yellowish pitch tubes (less than 1 / 4 inch), boring dust in bark crevices / base of tree, dead tops and groups of dead trees without pitchout tubes.

Harvesting Best Practices

Road Layout and design

1) Minimize the number of roads by using existing roads w whenever possible.
2) Grades should normally be kept below 10 percent.
3) Stream crossings should be kept to a minimum and carefully constructed.
4) Culverts and bridges should be designed to minimize impacts on the stream.
5) Permanent roads must be located, constructed, surfaced, and maintained carefully.
6) Temporary roads are designed to be closed and revegetated following use. Road construction activities should be limited to dry periods and period s of low or normal stream flows.

Streamside Management Zones

One of the best ways to protect water quality and other watershed values is to establish Streamside Management Zones (SMZ's) beside perennial streams. Intermittent streams, which may flow only during or immediately after a rain, normally do not require this level of protection.

Roads should not normally enter a designated SMZ except where a crossing is needed. Prior to beginning any road construction examine the entire area to determine the SMZ and locate any other especially sensitive areas, such as steep banks or springs.

Table 2. Guideline for Streamside Management Zone

Stream Width	SMZ Width (minimum)
Less than 20 feet	50 feet per side
20 feet to 40 feet	75 feet per side
More than 40 feet	200 feet per side

Slash Treatment

1) All whole trees and slash (green and brown needles) resulting from the thinning operation, prior timber harvest, past storm damage and insect / disease mortality will be skidded and piled along roadside landings, in-woods openings and meadows.

2) Old slash (gray, punky, lose bark and without needles) composed of dead / down trees from past storm damage or insect / disease mortality will be left in place; it will be driven over, crushed and reduced onto the soil surface via skidding operations.
3) All trees cut during thinning operations shall be felled so they lie on the ground
   a) No hang-ups or “jack strawing” will be allowed.
   b) No slash will be left up against "leave trees".
   c) Numerous small piles 8-10 feet diameter, are preferred to fewer large piles

Stump Height

1) Stumps shall be cut at a flat, 90 degree angle perpendicular to the tree trunk, not to exceed 12" in height on the uphill side.
2) Trees shall be completely severed from the stump and cut below the bottom green branches.

Firebreaks

Ridgelines

Locate firebreaks along ridgelines to minimize the potential of fires burning up south to west facing slopes to burn up and over the ridgeline as well as to provide access to firefighting vehicles and equipment

1) Create a firebreak along the ridgeline that is at least 66 feet (one chain) wide.
   a) All trees on south and west facing slopes should be cleared to a distance of at least 16.5 feet (one rod)
   b) All trees on the ridgeline (ridgetop) should be cleared to a width of at least 49.5 feet (three rods) and continue down the north and east facing slopes as necessary to achieve the total firebreak width of 66 feet.

Slopes

1) Thin post and pole-sized redcedar by separating individuals or groups to achieve target density, see stand density recommendations by slope below, to minimize catastrophic fire.

2) Remaining trees should be widely spaced with good crown separation. Trees must have a single stem and be at least six inches in diameter at breast height. See table below, ***Stand density recommendations by Percent slope***, for spacing recommendations.

Table 3. Stand density recommendations by percent slope

Percent Slope	Maximum Basal Area per Acre	Maximum Trees per Acre	Minimum Acceptable DBH	Approximate Spacing[1]
0 to 10%	90 ft^2	225	6	25’ by 25’
11 to 20	80 ft^2	150	8	35’ by 35’
21 to 30	70 ft^2	125	8	35’ by 35’
31 to 40	60 ft^2	85	10	50’ by 50’
41 to 50	50 ft^2	70	10	55’ by 55’
Greater than 50	40 ft2	55	10	60’ by 60’

Approximate spacing is minimum distance between groups of trees [crown to crown not stem to stem (bole to bole.)]

Roads

1) Remove all conifers (ponderosa pine and juniper species) and maintain grasses along established roads for a distance of at least 50 feet from centerline of the road (total width of 100 feet).

2) Hardwood species, no more than 40 ft^2 of basal area per acre, may be maintained in the firebreak. “Leave trees” with branches will be pruned (removal of side branches and low hanging branches) to 16 feet above ground.

3) All slash resulting from the thinning operation, prior timber harvest, past storm damage and insect or disease damage shall be mulched, shredded or chipped Refer to slash treatment above for treatment of all other slash.

4) Where applicable along county and state roads with a fenced right-of-way (ROW):
   a) Remove all conifers (ponderosa pine and juniper species) and maintain grasses within established ROW fence lines.
   b) Slash will be piled outside both ROW fence lines and mulched, shredded or chipped.
   c) Broadleaf trees and shrubs will not be cut unless their removal is warranted for vehicle safety.

Ladder Fuels along Meadows, Roads, or Trails

1) Meadow defined as an opening in the pine forest canopy of ¼ acre or larger.

2) Along all meadow road and trail edges, "leave trees" with branch foliage (green or brown) will be pruned up (removal of side branches low hanging branches) to 6' above ground.

3) Branches that originate higher than 6' above ground with foliage (green or brown) 6' or less above ground will have that foliage cut from the branches.

4) Pruning of branches 6' or less above ground will have smooth stubs no longer than ½" remaining.

Wildfire Defensible Space (Zones 1 and 2)

1) Highest priority fuel reduction zones nearest the home or structure; 300' minimum and 600' maximum radius with home / structure in the center.

2) “Leave trees” with branch foliage (green or brown) will be pruned up (removal of side branches or trimming back low hanging branches) to 6' above ground. Pruning of branches 6' or less above ground will have smooth stubs no longer than ½" remaining.

3) All slash resulting from the thinning operation, prior timber harvest, past storm damage or insect or disease shall be mulched, shredded, or chipped.

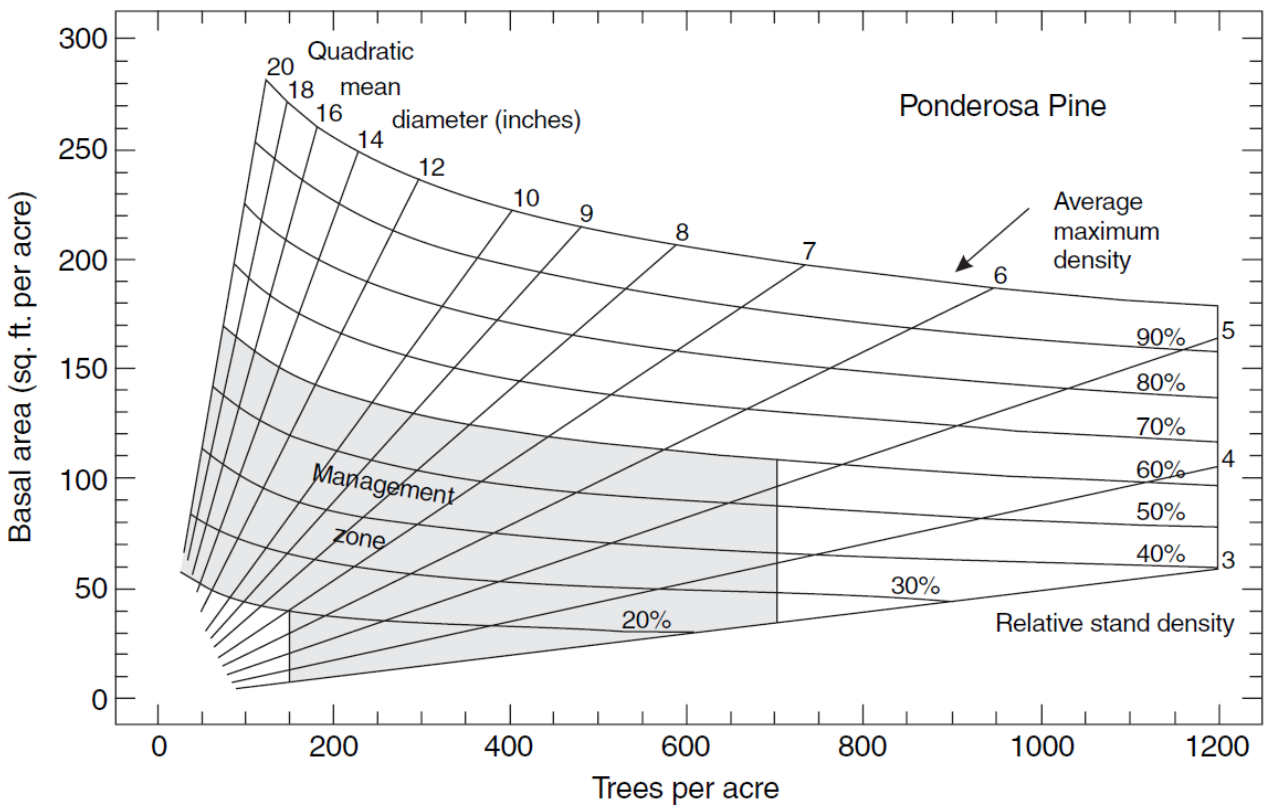

Figure 2--Gingrich stocking chart for even-aged ponderosa pine in Colorado. Average maximum density corresponds to SDI_{max}.

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