Appendix I
Silvicultural systems

Introduction

Background

The Report of the US Senate Committee on Agriculture and Forestry on the National Forest Management Act of 1976, to accompany S. 3091, states:

> In recognition of the fact that forests are extremely diverse, the Committee concluded that there are many factors which must be considered in selecting the proper silvicultural system in order to meet management objectives under plans. Therefore, the committee directed that the silvicultural systems to be prescribed should be appropriate to the forest type and represent the current state-of-the-art in scientific forest management.
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> In carrying out this provision, the Committee expects that the Secretary will identify, for the logical geographic areas, the silvicultural system or systems which have been found through research and experience to provide conditions for the prompt regeneration and growth of desirable tree species in order to meet multiple-use objectives set forth in the forest land management plan. It is recognized that silviculture can be utilized to achieve a variety of management objectives, in addition to that of timber production, wildlife, watershed, recreation, grazing, protection of the forest from insects and disease, and other multiple-use objectives can be advanced through application of various silvicultural methods and cutting techniques. All such uses and applications should be considered in the development of silvicultural prescriptions. In developing the prescriptions, the Secretary is expected to utilize findings of research by the Forest Service, as well as other sources and to consult with the committee of scientists established by the bill. In prescribing silvicultural systems, the Secretary will consider all resource objectives for the area as well as environmental factors, including economic and social impacts.

The implementing regulations of the National Forest Management Act require regional foresters to establish standards and guidelines for harvest cutting methods, prescribing the maximum size, dispersal and size variation of tree openings created by even-aged management; the state of vegetation that will be reached before a cut-over area no longer is an opening; and defining management intensities and utilization standards to be used in determining harvest levels (36 CFR 219.9).

These regional standards and guidelines have been published in the *Final Supplemental Environmental Impact Statement for Regional Guide Amendment*. Some of that information is included here to help the reader understand the major tree species or forest cover types on the Forest.

Forest cover types included in forest plan analysis are lodgepole pine, Engelmann spruce-subalpine fir, Douglas fir and aspen. These types make up the vast majority of species on the Forest (*see Appendix E*). Other species present but not significant enough to model include but are not limited to ponderosa pine, blue spruce, limber pine, bristlecone pine, cottonwood and piñon-juniper.

Engelmann spruce – subalpine fir

Engelmann spruce and subalpine fir (the spruce-fir forest) are widely distributed in Colorado and generally occur as the highest-elevation forest type, normally extending to timberline. These species usually occur as co-dominants within a stand, but can occur in nearly pure stands of one or the other. Associated trees on the Forest include limber pine, bristlecone pine, lodgepole pine, Douglas fir, and aspen. Engelmann spruce and subalpine fir tend to cover a well-defined altitudinal zone ranging from 9,000 to approximately 12,000 feet.

Spruce-fir forests grow in cold, humid climatic zones. These forests experience extremely short frost-free periods, usually lasting 60 days or less. Annual average precipitation ranges between 20 and 35 inches.

Engelmann spruce and subalpine fir are capable of forming stable stands. They probably are the most successful coniferous trees in the Rocky Mountains in terms of establishing new generations under the influence of their own shade. These species tend to maintain themselves on a site until changed by an external force such as fire. When fire occurs, spruce and fir often are replaced by lodgepole pine, aspen, or grassy parks, which slowly trend toward the climax spruce-fir community if left undisturbed. Lodgepole pine, aspen, and limber pine are, in most cases seral species of the spruce-fir community at higher elevations on better soils. On sites too dry for Engelmann spruce or subalpine fir, lodgepole pine and aspen form stable stands within the general Engelmann spruce-subalpine fir forest.

Both Engelmann spruce and subalpine fir grow slowly. Engelmann spruce trees grow to 18 to 30 inches DBH and 80 to 100 feet in height when they reach maturity at 250 to 300 years of age. Subalpine fir trees are smaller than Engelmann spruce, reaching 18 to 24 inches DBH and 60 to 100 feet in height when they mature at 150 to 200 years of age.

Fir seedlings become established on a variety of seedbeds and do well in deep shade. Subalpine fir is very tolerant of shade, allowing it to exist in the understory of Engelmann spruce stands.

Both Engelmann spruce and subalpine fir seedlings grow slowly. Because spruce and fir grow on moist, cool sites, they typically have very shallow roots. For this reason, both species are very susceptible to windthrow, especially if stands are suddenly opened extensively by timber harvest. Usually no more than 30 to 40 percent of the basal area should be removed in order to prevent windthrow. Because trees develop interdependence for protection from the wind, care is exercised when trees are to be removed.

Engelmann spruce is susceptible to the spruce bark beetle, which attacks older, larger, less vigorous trees. Infestations commonly occur in groups of trees on more moist sites. Engelmann spruce also is vulnerable to numerous wood-rotting fungi, which either kill the tree or cause it to break or fall. Subalpine fir is highly susceptible to rot and has a much shorter pathological age of maturity than does Engelmann spruce.

Given the shade tolerance of Engelmann spruce and subalpine fir, coupled with susceptibility to insects, disease, and blowdown, many stands develop more than one age class and may become uneven-aged stands. Depending on how they develop, stands can be one-, two-, three-, or multi-storied. Regeneration occurs almost continuously throughout the stand in openings resulting from blowdown or insect infestation. This accounts for the clumpy structure in many old-growth stands.

Lodgepole pine

Lodgepole pine occurs on the Forest primarily in even-aged stands originated by a fire event. These forests occur mainly in the drier coniferous regions, but also can be found in very dry (xerophytic) conditions and in the subalpine coniferous region. Lodgepole pine is associated with numerous forest types, including Engelmann spruce-subalpine fir, ponderosa pine, Douglas fir and aspen.

Lodgepole pine is distributed uniformly throughout northern Colorado and sporadically in central Colorado. Because the species has a broad range of temperatures and moisture tolerance, it can be found everywhere from warm, dry lower elevations, associated with ponderosa pine, to the cool, moist higher-elevation zones. Lodgepole pine forests range from between less than 8,000 to more than 10,500 feet in elevation.

The climate affecting lodgepole pine forests is variable. Average annual precipitation ranges from 15 to 30 inches, with higher elevations receiving more precipitation than lower elevations. The growing season is generally short, averaging between 60 to 100 days in most areas. Mean annual temperatures are between 30º and 40º F.

Lodgepole pine has long been regarded as a fire-maintained subclimax type. Its ability to regenerate in extremely dense stands to the exclusion of other species can be attributed to closed cone habitat. Occasionally seedlings become established under a forest canopy, but these individuals rarely do well. In spite of its shade intolerance, lodgepole pine maintains itself in dense stands for long periods. Lodgepole pine reaches maturity at 120 to 140 years of age and can remain in a healthy condition up to 200 years of age. Tree height and diameter depend on the density of trees and site quality. On favorable sites, trees reach 10 to 13 inches DBH and 60 to 90 feet in height.

In the absence of fire, lodgepole pine usually is succeeded by its more tolerant associates, such as Engelmann spruce and subalpine fir.

The mountain pine beetle is the most severe insect pest of lodgepole pine. During low (endemic) population levels, mountain beetles are difficult to find. Just how the transition from endemic to epidemic populations occurs is unknown. Before an outbreak can occur, however, certain stand conditions conducive to buildup of beetle populations are essential. Those that have been identified for lodgepole pine stands are: (1) average diameter greater than eight inches for trees five inches and larger DBH; (2) average age about 80 years or older; and (3) climatic suitability for beetle development.

Dwarf mistletoe is the most serious disease affecting lodgepole pine forests. Mistletoe seeds are forcibly ejected from the fruit for distances as great as 30 feet. The sticky seeds adhere to the foliage of potential host trees. The proportion of trees visibly infected can double each five years between the ages of 10 and 25, with nearly a third of the trees infected at age 25.

Dwarf mistletoe infection results in reduced diameter and height growth, increased mortality, reduced wood quality, decreased seed production, and overall decreased vigor.

Dwarf mistletoe reduces growth and increases the mortality of these trees. Because the disease propagates by shooting spores to adjacent branches, it is extremely difficult to control dwarf mistletoe in uneven-aged lodgepole pine stands that exhibit vertical structure. The profusion of branches and different size trees in uneven-aged stands makes it very easy for the disease to spend quickly through such stands.

Lodgepole pine bears an abundance of closed cones. However, it is not uncommon to have both closed-cone habitat and open-cone habitat in the same stand. In stands with closed-cone habitat, the most important form of seed dispersal is release from cones attached to slash or cones scattered on the forest floor. Maximum release from this source takes place the first year after disturbances such as fire or timber harvest. In stands with open-cone habitat, seed is dispersed from standing trees, largely by the wind.

Aspen

Aspen is a deciduous tree noted for its brilliant gold fall colors. It frequently is associated with and lies between coniferous forests (Douglas-fir, Engelmann spruce-subalpine fir, lodgepole pine and ponderosa pine) and mountain grassland parks and meadows. Aspen is widely distributed throughout Colorado; however, aspen is best developed in the central and southwestern areas of the State, where trees often reach 24 inches in diameter and 100 feet in height at elevations ranging between 6,000 and 10,500 feet.

Annual precipitation ranges from 15 to 40 inches and mean annual temperatures average between 30º and 40º F in most areas.

Although clonal characteristics affect stand structure, varying situations can cause aspen trees to grow in even-aged, two-storied, or uneven-aged stands. Uneven-aged stands can develop from repeated fires in which not all of the trees are killed. A similar situation can result when individual trees are killed or when individual trees die from old age, insects, or diseases. Even-aged stands result from a major disturbance such as intense fire or clearcutting.

Aspen matures between 80 and 100 years of age, after which it begins to deteriorate because of disease. On better sites, mature aspens reach 16 to 24 inches DBH and 85 to 100 feet in height.

In the absence of disturbance that would stimulate regeneration, stands normally will deteriorate and die. Conversions to associated types require varying amounts of time, depending on a number of factors such as the frequency of fire, the extent and intensity of browsing, disease, stand density, and altitude.

Aspen generally is very intolerant to shade and must have full sunlight to grow and reproduce. It is less shade tolerant than any of the species with which it normally is associated.

Aspen is susceptible to a large number of diseases that include leaf blights, leaf rust fungi, mildew, viruses, bacteria, stains and decays. Decay fungi cause the greatest losses in aspen. The incidence and extent of infestation increases with tree age or size.

Douglas fir

Douglas fir is distributed throughout Colorado, occurring at elevations ranging from 7,000 to 10,000 feet. It occasionally reaches climax at elevations between 7,000 and 8,500 feet, but more commonly between 8,500 and 9,500 feet. Douglas fir occurs on sites where precipitation averages between 20 and 25 inches with mean annual temperature average between 30º and 40º F.

Although Douglas fir is the diagnostic and dominant overstory species, it may be far from uniform, often occurring intermixed with other conifers such as ponderosa pine, lodgepole pine, Engelmann spruce and subalpine fir.

After extreme disturbance, such as timber harvesting or fire, Douglas fir stands in Colorado often return immediately to the Douglas fir type.

Douglas fir is considered to be a climax species. After fire, a stand may be replaced by aspen, lodgepole pine or may remain as Douglas fir, depending on seed source and soil conditions. Douglas fir reaches maturity at 200 years of age with DBH between 15 and 30 inches. Mature stands can be maintained to an age of 350 to 400 years.

Douglas fir dwarf mistletoe is one of the most damaging parasites and the Douglas fir beetle and spruce budworm are the more important insect enemies.

Silvicultural systems

> "The silvicultural system can be viewed as the process by which we grow a forest stand for a specific purpose. This process includes all practices over a rotation—harvest or regeneration cuttings, intermediate cuttings, and other cultural treatment—necessary for replacement and development of the forest stand"(Burns 1983).

The two main types of silviculture systems in use on the Forest are the even-aged and uneven-aged systems. The two-aged system also is used on the Forest but not to any great extent. Under the two-aged system, irregular shelterwood regeneration methods have been used. Refer to the glossary (Appendix L) for a definition of two-aged methods and the types of methods included in the two-aged system.

Systems proposed for use in each type are:

- *In spruce-fir* – the two-step, three-step shelterwood, irregular shelterwood, and individual and group tree selection
- *In lodgepole pine* – clearcutting, two-step, three-step shelterwood, irregular shelterwood, and group selection
- *In aspen* – coppice cutting
- *In Douglas fir* – two-step, three-step shelterwood, irregular shelterwood, and individual and group tree selection.

EVEN-AGED MANAGEMENT

Davis (1966) defines even-aged management in which the dominant trees originated at about the same time, and, following a period of protection as under a shelterwood, develop under full-light conditions without significant border competition. Such a stand is even-aged regardless of size.

In even-aged management the difference in age between trees forming the main canopy level of a stand usually does not exceed 20 percent of the level of a stand that has reached the desired age or size for regeneration, and is harvested.

Cutting methods producing even-aged stands are clearcut, shelterwood and coppice.

Clearcutting harvests all merchantable trees and regenerates the entire stand at one time.

> "Reproduction is obtained by natural seeding from adjacent stands or from trees cut in the clearing operation, or it is obtained artifically through planting or direct seeding" (USDA May 1992).

> "Clearcutting is aesthetically the least desirable of the harvest methods. However, the undesirable appearance of the harvested area is temporary and can be improved through careful location of boundaries to fit the landscape, appropriate cleanup of logging debris, and prompt establishment of reproduction" (Burns 1983).
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> "Clearcutting silviculture is the most appropriate system for effectively regenerating those species of trees which naturally grow in even-aged stands and which cannot regenerate in the stand of other trees. Aspen and lodgepole pine are these kinds of trees" (USDA May 1992).
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> "Clearcutting silviculture has a very important environmental implication for forests in the Rocky Mountain Region. Clearcutting silviculture is done in such a way that trees are logged in an area and then left to grow for a relatively long period of time. This means that roads can be built and then closed to traffic or physically removed and the land restored, and that mechanical equipment is used on the harvest site for only a short period of time because clearcutting requires only temporary roads and infrequent operation of mechanical equipment, streams and soils can recover from the impacts of clearcutting through natural processes" (USDA, May 1992).
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> "Clearcutting ... most nearly matches the role formerly played by forest fires ... is often considered the optimum method for regenerating aspen, lodgepole pine with serotinous cones ... is also the most effective method for treating stands heavily infested with dwarf mistletoe ... and is often the only practical method to use in stands of late-successional species that have deteriorated to the point where there is an insufficient number of good trees for selection or shelterwood methods to be effective" (Burns 1989).

The National Forest Management Act (NFMA) directs the Forest Service to "Insure that clearcutting ... and other cuts designed to regenerate an even-aged stand of timber will be used as a cutting method on National Forest System lands only where for clearcutting, it is determined to be the optimum method ... to meet the objectives and requirements of the relevant land management plan."

The Report of the US Senate Committee on Agriculture and Forestry on the NFMA of 1976, to accompany S. 3091, states:

> The term optimum method means it must be the most favorable or conducive to reaching the specified goals of the management plan. This is, therefore, a broader concept than silviculturally essential or desirable, terms considered and rejected by the Committee. The Committee had substantial discussion over how to define when it was appropriate to use even-aged management systems. There was full agreement that the decision should not be based solely on economic benefits, i.e. dollar benefits or return dollars. Rather, the full scope of environmental effects (natural, economic, and social) should be evaluated and even-aged systems should be used only when they best meet forest management objectives for the individual management plan. Further, the monitoring, evaluation, and research processes will be used in the process.

The Chief of the Forest Service has established policy on clearcutting as follows:

> Apply clearcutting only where it has been found to be the optimum method of regeneration to meet multiple-use objectives and is essential to meet forest plan objectives, involving one or more of the following circumstances:
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> 1. To establish, enhance, or maintain habitat for threatened, endangered, or sensitive species.
> 2. To enhance wildlife habitat or water yield values or to provide for recreation, scenic vistas, utility lines, road corridors, facility sites, reservoirs, or similar development.
> 3. To rehabilitate lands adversely impacted by events such as fires, windstorms, or insect or disease infestations.
> 4. To preclude or minimize the occurrence of potentially adverse impacts or disease infestations, windthrow, logging damage, or other factors affecting forest health.
> 5. To provide for the establishment and growth of desired trees or other vegetative species that are shade intolerant.
> 6. To rehabilitate poorly stocked stands due to past management practices or natural events.

Determination of optimal clearcutting and adherence to the above policy will be decided on a project-specific basis and is not part of the 2002 Forest Plan.

Shelterwood In the shelterwood system, "the next stand of trees is established through natural and/or artificial regeneration before the old one is completely removed. In a series of cuts, trees are removed, leaving the more desirable species and healthier trees to provide seed, protect the young seedlings, and increase in volume for the final cut. The three-step shelterwood process usually involves a series of three operations: (1) preparatory cuttings designed to stimulate seed production and prepare the seedbed; (2) seed cuttings to establish the new crop of trees; and (3) removal cutting to release the established seedling and harvest the overstory trees" (Burns 1989). About one-third the volume of the stand is taken out in each of the above cuts. In the two-step shelterwood cut, usually just the seed production and removal cuts are completed, usually removing 40-60 percent of the volume in each cut. In an irregular shelterwood system, normally a three-step system, the last step or removal of the overstory trees is not re-accomplished. This creates somewhat of a two-storied or two-aged stand.

Coppice The coppice system is very similar to clearcutting except that the future stand usually occurs from stumps or root sprouting, and residual non-merchantable trees are cut to promote sprouting.

UNEVEN-AGED MANAGEMENT

Uneven-aged management is a condition of forest or stand that contains intermingled trees that differ markedly in age. By convention, a minimum range of 10 to 20 years is generally accepted, though with rotations of not less than 100 years, 25 percent of the rotation may be the minimum.

Selection In single-tree or group selection, trees are removed either individually or in groups based on age, merchantability, health, seed production capability, and potential to increase in volume and quality. Single-tree selection creates very small openings. In group selection, the openings can be up to two acres. Single-tree selection is more favorable for reproducing species that can grow in the shade (shade-tolerant) over those that require direct sunlight. "Therefore the single tree selection method is not appropriate for regenerating shade-intolerant species" (Burns 1989). The size, shape and placement of openings can be varied to meet the light requirements of the species being regenerated. Also, opening size is determined by the silvical characteristics of the trees, their size and the ease by which they can be removed without damaging other vegetation.