SILVICULTURAL MANAGEMENT ALTERNATIVES FOR WHITEBARK PINE

Douglas E. Eggers

ABSTRACT

Whitebark pine (Pinus albicaulis) *has received little management emphasis except in the past 10 years. Silvicultural treatment of whitebark pine is starting to draw increased interest as attention is focused on the species and its potential management. The objective of this paper is to summarize what is currently known about the silvicultural management of the species. There has been little written concerning silvicultural treatment in whitebark pine stands; however, there are some inferences that can be drawn by examining specific examples. These examples will be used to demonstrate that information does exist and that these existing data will probably need to be used to guide management while additional data are gathered and understanding is gained.*

SILVICULTURAL OBJECTIVES

The most important factor to keep in mind (and the one so often neglected) when examining silvicultural management alternatives for whitebark pine (*Pinus albicaulis*) is the need to identify clear, accomplishable, land management objectives. Daniel and others (1979) described the role of silviculture in forest and wildland management. Formulating silvicultural strategies requires the recognition of biological, managerial, and economic considerations. For example, objectives for recreation, water production, wildlife, or wood may require forests with different structures. Translating those objectives into specific kinds of stand structures and composition then becomes a matter of silvicultural application. This silvicultural application involves a basic understanding of principles that will in turn translate into recommended practices. This paper will not address different land management objectives other than showing how they may affect treatments. The assumption is made that the perpetuation of the whitebark pine component is desired.

In translating land management objectives into tangible, specific activities, it is important to define the subject using accepted forestry terminology. The terms used here are taken primarily from the Society of American Foresters' publication, "Terminology of Forest Science, Technology, Practice and Products" (Ford-Robertson 1971).

The first definition, silviculture, is fundamental to the rest that will be presented in this paper. Silviculture is defined as follows:

1. Generally, the science and art of cultivating (growing and tending) forest crops, based on a knowledge of silvics.
2. More particularly, the theory and practice of controlling the establishment, composition, constitution, and growth of forests (Ford-Robertson 1971).

The definition can be refined further to understand that silvics is: "The study of the life history and general characteristics of forest trees and stands, with the particular reference to locality factors, as a basis for the practice of silviculture" (Ford-Robertson 1971). Examination of the "theory and practice of controlling the establishment, composition, constitution, and growth" of whitebark pine based on what is known about its life history and general characteristics, using some specific references to locality factors, will be the focus of this paper. The specific examples given will utilize what is known of current stand structure and knowledge of stand history as well as ecological information to project the treatments necessary to produce the desired future conditions.

CONTROLLING ESTABLISHMENT

Controlling establishment involves "The process of developing a crop to the stage at which the young trees may be considered established; i.e., safe from normal adverse influences—e.g., frost, drought, weeds or browsing—and no longer in need of special protection or special tending, but only routine cleaning, thinning, and pruning" (Ford-Robertson 1971).

The process of developing a crop of whitebark pine to the stage that it is considered established or free to grow starts with regeneration. Daniel and others (1979) distinguished between silvicultural reproduction (regeneration) methods and silvicultural systems: a regeneration method describes the manner of cutting to ensure regeneration and a silvicultural system describes additionally the process for treating the resulting stand after establishment. Attention will be focused on regeneration rather than on silvicultural systems. The regeneration methods that could be used in whitebark pine stands, according to Arno and Hoff (1989), would be either even-aged or uneven-aged depending on site factors and management objectives. Even-aged regeneration methods are clearcutting,

Paper presented at the Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource, Bozeman, MT, March 29-31, 1989.

Douglas E. Eggers is Forest Silviculturist, Bridger-Teton National Forest, Forest Service, U.S. Department of Agriculture, Jackson, WY.

seed tree, and shelterwood. Uneven-aged regeneration methods are single tree and group selection. These various methods form a continuum, as described by Daniel and others (1979); the amount of site exposure that results ranges from the least, with single tree selection, to the greatest, with clearcutting.

The silvical characteristics of whitebark pine including irregular large cone crops, uncertain seed dissemination, and low seed germination, will narrow the range of silvicultural options that are feasible for any particular site.

There has been little management activity in northwestern Wyoming that has focused directly on whitebark pine. Only in recent years has there been much attention given to whitebark pine, therefore, there is not the amount or detail of data available that there is for some other species. However, observations have been made that should be valuable in evaluating the appropriateness of prescribing various regeneration methods. The types of data, such as timber inventory data, that exist for the Bridger-Teton National Forest, also exist for most other National Forests.

Arno and Hoff (1989) noted that whitebark pine often regenerates following wildfire and after clearcutting (with or without site preparation) on southern exposures or ridgetops. They also observed that to regenerate whitebark pine on moist sites, appreciable stand opening and localized site preparation would probably be necessary. Arno and Hoff (1989) found that whitebark pine can be regenerated artificially by using seedlings or seeds in mineral soil or at the soil-litter interface. Eggers (1986) has noted various artificial regeneration methods that could be utilized.

The author has made observations on a study site located in the Union Pass area of the Bridger-Teton National Forest that was set up in 1971 to evaluate several methods of harvesting mature lodgepole pine (*Pinus contorta* Dougl. ex Loud.) and to compare postharvest treatments (Benson 1982). These observations have shown that whitebark pine seedlings are becoming established on this site. The greatest number of seedlings is located in the areas that received the treatment of clearcut, tractor pile, burn, and plant. This stand, prior to harvest, had over 1,500 stems/acre of whitebark pine under 5.0 inches d.b.h. These seedlings, which became established under the closed canopy of the predominately lodgepole pine stand over its 160-year life span, were of poor quality and arranged in a clumpy pattern (Benson 1982). The evidence would indicate that if there is whitebark pine in surrounding stands, within 10 to 15 years there will be some stocking of whitebark pine in clearcuts.

At this relatively moist, higher elevation (9,200 ft) where strong winds are experienced during the winter, it is probable that some seed dispersal takes place from seeds being blown along on crusted snow. There could be some dispersal by rodents or birds, however, the pattern of occurrence corresponds to that of seedlings of other species started from wind-borne seed. There were more seedlings observed on the north and northeast sides of the planted lodgepole pine, which would seem to indicate that some degree of shading may benefit establishment. The whitebark pine seedlings found in this area are single and not clustered as they would be if a whole cone disintegrated on the ground and the seeds germinated.

One of the factors that has contributed to the seedling establishment of all species in this area is the wet seasons that occurred during the mid-1980's. It is also interesting to note that observations made in late 1988, after one of the driest years on record, confirmed that a number of first- and second-year seedlings were still alive. This would indicate that after germination, vigorous rooting takes place, thereby aiding survival.

There have been questions raised on the value of releasing understory whitebark pine. My observations, made primarily in mixed species stands in which whitebark pine is a component, of the growth response of residual seedlings and saplings of whitebark pine after release have indicated that residual seedlings and saplings have responded little to release. The observations were made in clearcuts and in stands with various levels of partial cutting (some regeneration harvests and some intermediate harvest). This is an area that needs additional data to determine more of the specific characteristics of the residuals such as age at release and average growth prior to release.

The inference that can be drawn from these observations is that whitebark pine establishment is enhanced by bare mineral soil and an abundance of moisture. Germination is one of the most critical factors known at this time. Answers to the whys of poor germination are currently unknown. Pitel and others (1980) indicated that there appears to be a relationship between the completeness of development of the embryo and the condition of the seed coat that affects germination. The factors at work here are important, but personal observation has shown that more seedlings are visually evident after a wet season, particularly a wet spring, than any other time. More moisture is permeating the seed coat, thereby aiding germination, whatever the mechanism is for breaking down seed dormancy.

There are silvical characteristics important to establishment that can be controlled with some degree of predictability. Seed production, is one such characteristic. Flowering and fruiting is an integral part of seed production and can be influenced by the application of spacing control to produce trees with a higher proportion of crowns that are fully exposed to light (Daniel and others 1979). Techniques used in seed production areas such as thinning, fertilization (after foliar analysis), and protection from insects and other seed destroying agents could also be used.

Regeneration methods that recognize the basic silvical needs of the species will be the most successful. Additional examples are described by Arno and Hoff (1989), such as a rooting habit that develops a deep spreading system. The root system is well-anchored in the rocky substrate and is seldom disturbed despite the tree's large, exposed crown and the violent winds to which it is subjected. They also indicated that while whitebark pine had previously been reported as very intolerant, more recent observations show that it would be more accurate to classify it as intermediate in tolerance to shade.

Whatever regeneration method is chosen, the retention of healthy, windfirm seed trees with good phenotypic characteristics will aid in natural regeneration. It is important to realize that regeneration through natural regeneration alone will probably mean long regeneration periods. These regeneration periods may be decades, in comparison to a few years for such associated species as Engelmann spruce or lodgepole pine. The characteristic that whitebark pine is intermediate in tolerance would indicate that there will be some seedlings that become established.

Using the Bridger-Teton National Forest as an example, in the short term, if the whitebark pine component is to be increased or its range is to be extended, artificial regeneration will be necessary. If this option is chosen, it will be very expensive to carry out on an operational basis. It is not an easy solution, as described by Eggers (1986), but one that could be carried out if management emphasis and budget were committed to it.

CONTROLLING COMPOSITION

Composition is defined by the Society of American Foresters (Ford-Robertson 1971) as the "species composition of a forest crop or stand, the representation of tree species in it. This is expressed quantitatively as percent by volume or basal area of each species; percent by number only at the seedling stage."

The species composition that is desirable may be dependent on the land management objectives, but what is possible will be dependent on inherent characteristics such as site quality, habitat type capabilities, and presence or absence of pest agents. Whitebark pine, Society of American Foresters Cover Type 208, (Eyre 1980) is used to designate pure stands or mixed stands in which the species comprises a plurality of stocking. It is necessary to know the existing vegetation to formulate a better prescription for what is desired. For example, in the over 50 forest habitat types identified in the eastern Idaho-western Wyoming area, whitebark pine was found in 36. On the Bridger-Teton National Forest, whitebark pine occurs with lodgepole pine, limber pine (*Pinus flexilis* James), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.), Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco), and aspen (*Populus* spp.). The single-stemmed growth form is most commonly associated with a plurality of lodgepole pine. The multi-stemmed growth form is more commonly found with a plurality of whitebark pine at the extremes of environmental conditions. Common shrub and herbaceous associates are listed in "Forest Habitat Types of Eastern Idaho-Western Wyoming" (Steele and others 1983). This publication lists the percentage canopy coverage by species and the constancy or the percentage of stands in a habitat type that contain a given species.

Controlling the species composition begins with establishment, through the favoring of trees left for seed or artificial reforestation. The time between establishment and the next regeneration period can be used to perform a whole range of stand manipulations, generally termed intermediate treatments, to control the species composition. Cleaning, weeding, liberation, and improvement cuttings could be used at various stages of stand growth, singly or in combination, to achieve the land management objectives.

CONTROLLING CONSTITUTION

Constitution is the "structure, of a forest crop or stand, the distribution and representation of age and/or size classes" (Ford-Robertson 1971).

Land management objectives will guide the controlling of distribution of age and size classes of whitebark pine and specific stand structures: the relative proportion of overmature (declining in vigor, health, or soundness), mature (full development of height and seed production), saplings, and seedlings. Success requires an understanding of stand dynamics including succession, competition, and tolerance. This can be aided by the identification of habitat types as described in the previous section. The various pathways of succession are affected by the starting point. The progression toward climax vegetation will continue without treatment, but the character of the stand can be changed through treatment. The silviculturist can control the structure by applying various treatments including harvesting, site preparation, controlling species composition, and thinning. These choices will affect the ways individual trees and species will respond. These choices may range from broad to narrow in the short term depending on the character of the existing stands.

An illustration from the Bridger-Teton National Forest timber inventory information will help to put this into perspective. Examining the timber inventory plot data has given a profile of the existing condition of the whitebark pine resource:

Characteristic	Average for whitebark pine
d.b.h.	14.9 inches
height	51 feet
d.b.h. age	157 years
past 10 yrs. radial growth	0.25 inches (range 0.1 to 0.9)
best 10 yrs. radial growth	0.8 inches (range 0.25 to 2.25)
age of best growth	20 years
elevation	9,000 feet

These facts should help when writing prescriptions that will be able to be implemented. What does an analysis of these data show? It shows that for the Bridger-Teton National Forest, the whitebark pine is a mature/overmature resource that is currently growing slowly, but at younger ages is capable of growing as well as its associates.

CONTROLLING GROWTH

Growth is described as: "increment, accretion. The increase in girth, diameter, basal area, height, volume, quality or value of individual trees or crops" (Ford-Robertson 1971).

The definition of growth covers the whole range from individual trees to entire forest. Land management objectives should indicate the relative importance of various growth factors. This could mean quality or value in terms of such characteristics as multi-stemmed growth habit, foliar biomass, or consistently large seed crops.

There are basic standards that should be reviewed to be able to set realistic growth expectations. A number of these have been described in earlier sections. There are givens. For example, the height that a tree can reach at a certain age on a particular site is largely limited by soil and climatic factors. Different species respond differently to differing site quality. It is important to recognize that whitebark pine grows over a range of climatic conditions but is characterized by Arno and Hoff (1989) as growing in cold, windy, snowy, and generally moist conditions. They indicated that in moist mountain ranges, whitebark pine is most abundant on warm, dry exposures and in semiarid ranges it becomes prevalent on cool exposures and moist sites. The mean annual precipitation for most stands where whitebark pine is common is between 24 and 72 inches with about two thirds of the precipitation coming in the form of snow and sleet.

In considering environmental factors affecting growth of whitebark pine stands, two of the most important are insects and disease. The most damaging insect pest of whitebark pine is the mountain pine beetle (*Dendroctonus ponderosae* Hopkins). There has been a significant amount of mortality in mature stands throughout the northern Rocky Mountain area Arno and Hoff (1989). This insect may kill individual trees even at higher elevations but most whitebark pine tree killing in northwestern Wyoming occurs when beetle populations build up in lodgepole pine stands at lower elevations. Management in lower elevation stands may need to increase to lessen the impact on higher elevation stands. Mountain pine beetle has caused severe damage to some whitebark pine stands. The principal disease that causes damage to whitebark pine is white pine blister rust (*Cronartium ribicola*); it usually results in death in sapling and pole-sized trees and top killing in mature trees.

We also need to recognize that basic tree physiological principles are at work even though we may not know or recognize them all for whitebark pine. Examples are: the major reasons why understory may not respond after release are that poor root systems can't use the increased nutrients, low live crown ratio won't allow adequate food production, or advanced age decreases ability to respond.

In the area of growth, as in establishment, composition, and constitution, there are some specific examples from data collected in unmanaged stands that can be used to illustrate what is known. From these examples inferences can be drawn on the expectations from stand manipulations. The major growth factors that can be affected by management activities are: controlling composition and manipulating density.

The following examples from the Bridger-Teton National Forest will help to demonstrate:

The best whitebark pine height growth on the Bridger-Teton National Forest (as evidenced by the greatest number of plots with trees over 70 ft in height) was recorded at elevations between 8,300 and 9,100 ft.

The most prevalent habitat type for these plots was *Abies lasiocarpa / Vaccinium scoparium-Vaccinium scoparium* phase. The *Abies lasiocarpa* Series is the most prevalent on the Forest and *Vaccinium scoparium* is the most prevalent habitat type in the *Abies lasiocarpa* Series. The yield capability for this habitat type is quite broad, ranging from 20 to 90 cubic ft per acre per year (Steele 1982). The inventory data showed that on the above habitat types we can expect a tree that is 17 to 20 inches d.b.h. and over 70 ft tall to be between 150 and 175 years old. Trees that are over 30 inches d.b.h. and over 90 ft tall are usually at least 220 years old. One of the larger specimens recorded on the inventory plots was 38.1 inches d.b.h., 111 ft tall and 281 years old. We can also infer from the inventory that the growth pattern after establishment could follow the progression shown in table 1.

It will help lend perspective to the observations by recognizing that in terms of relative productivity, the Bridger-Teton National Forest has the highest overall productivity of any National Forest in the Intermountain Region of the Forest Service. The Bridger-Teton's average productivity potential is 63 ft^3/acre/yr, (USDA Forest Service 1980) which compares to an average of 64 ft^3/acre/yr for the Rocky Mountain area as a whole (USDA Forest Service 1982).

Table 1—Growth examples at various ages from Bridger-Teton National Forest inventory

Age	D.b.h.	Height
Years	*Inches*	*Feet*
25	5.3	21
40	10.8	41
70	12.6	67
100	13.7	71

CONCLUSIONS AND RECOMMENDATIONS

It would seem that whitebark pine is neither the mystical nor mysterious species that some have made it out to be, but one for which a broader base of knowledge is needed. The attention focused recently on whitebark pine due to its relationship with grizzly bear habitat has helped to add to the knowledge base. We need to use the information, such as timber inventory plot information, that is currently available until more site-specific information for particular stands is collected. By observing what has happened in stands that have been entered, a silviculturist should be able to determine appropriate ways to manipulate individual stands to meet land management objectives. These land management objectives need to be clearly stated in quantifiable terms. We can then work toward developing the types of stands that we desire, while recognizing that it will take a considerable amount of time to get them.

Future research and information needs:

1. Continue to refine nursery propagation techniques,
2. Continue the genetic work to determine variability in whitebark pine,
3. Delineate and define objectives for those stands that need management prescriptions, and gather the site data needed.

REFERENCES

Arno, Stephen F.; Hoff, Raymond J. 1989. Silvics of white bark pine (*Pinus albicaulis*). Gen. Tech. Rep. INT-253. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 11 p.

Bailey, D. K. 1976. *Pinus albicaulis*. Curtis Botanical Magazine. 180(3): 141-147.

Benson, Robert E. 1982. Management consequences of alternative harvesting and residue treatment practices—lodgepole pine. Gen. Tech. Rep. INT-132. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 58 p.

Daniel, Theodore W.; Helms, John A.; Baker, Frederick. 1979. Principles of silviculture. New York: McGraw-Hill. 500 p.

Eggers, D. E. 1986. Management of whitebark pine as potential grizzly bear habitat. In: Contreras, G. P.; Evans, K. E., eds. Proceedings—grizzly bear habitat symposium. Gen. Tech. Rep. INT-207. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 170-175.

Eyre, F. H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p.

Ford-Robertson, F. C., ed. 1971. Terminology of forest science, technology practice and products. Washington, DC: Society of American Foresters. 349 p.

Pitel, J. A.; Wang, B. S. P. 1980. A preliminary study of dormancy in *Pinus albicaulis* seeds. Canadian Forest Service Bi-Monthly Research Notes. 36(1): 4-5.

Steele, Robert; Cooper, Stephen V.; Ondov, David M.; Roberts, David W.; Pfister, Robert D. 1983. Forest habitat types of eastern Idaho-western Wyoming. Gen. Tech. Rep. INT-144. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 122 p.

USDA Forest Service. 1980. Environmental consequences of timber harvesting in Rocky Mountain coniferous forests. Gen. Tech. Rep. INT-90. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 526 p.

USDA Forest Service. 1982. An analysis of the timber situation in the United States 1952-2030. Forest Resource Report No. 23. Washington, DC: U.S. Department of Agriculture, Forest Service. 499 p.