SILVICULTURE OF SPRUCE-FIR FORESTS IN THE CENTRAL ROCKY MOUNTAINS

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Silviculture Of Spruce-Fir Forests In The Central Rockies

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Engelmann spruce (*Picea engelmannii* Parry) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) comprise the spruce-fir forest type within the Central Rocky Mountain subalpine zone, the highest forested area in the states of Wyoming, Colorado, and northern New Mexico. The diversity of climate and habitat types in this subalpine zone has long been recognized by foresters and ecologists.

This diversity makes the practice of silviculture within these forests a unique and sometimes complicated art. The potential impacts of the variety of uses for subalpine forests makes it increasingly important that forest managers and silviculture practitioners understand the relationships of these species to their environment.

This booklet and the accompanying slide-tape presentation are designed to provide a concise summary of the ecological relationships within spruce-fir forests and the silvicultural practices available for use in these forests. Please keep this booklet as a handy reference to help you recall the subjects presented in the talks, and also locate additional literature in which you can find the original research covering the topics. You can obtain copies of the references cited by contacting the WESTFORNET library network at 240 West Prospect, Fort Collins, CO 80526.

This spruce-fir slide-tape presentation and booklet have been distributed to all National Forests in the Central Rocky Mountain area that manage this forest type. Information concerning the purchase of additional copies of this or other slide-tape and booklet sets can be obtained from the Regional Offices for the USDA Forest Service Rocky Mountain and Southwestern Regions or by writing:

Public Affairs Officer
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240 West Prospect
Fort Collins, CO 80526

[1]*Headquarters is in Fort Collins, in cooperation with Colorado State University.*

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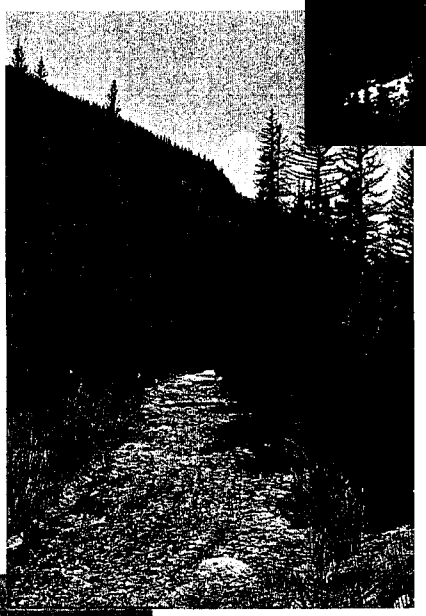
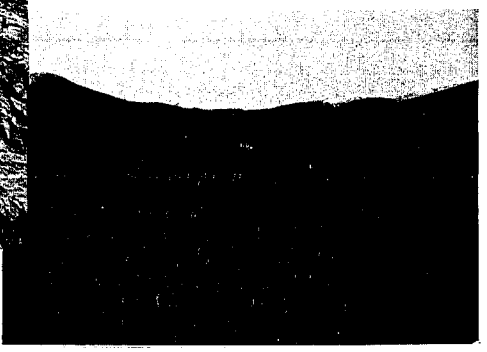
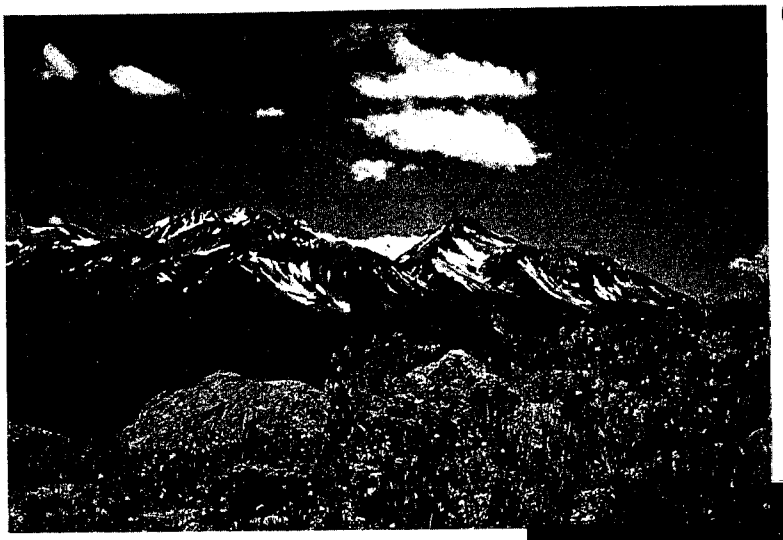




1. . . . **2.** . . . **3.** . . . **4.** . . . (musical interlude) . . .

5. The high country of Colorado, southern Wyoming, and northern New Mexico includes . . .



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6. . . . a harsh, unforgiving land of rugged topography, with microclimatic extremes, short growing seasons, and shallow, poorly developed soils. Here grows the most productive forest type in the Rocky Mountain region: Engelmann spruce/subalpine fir.

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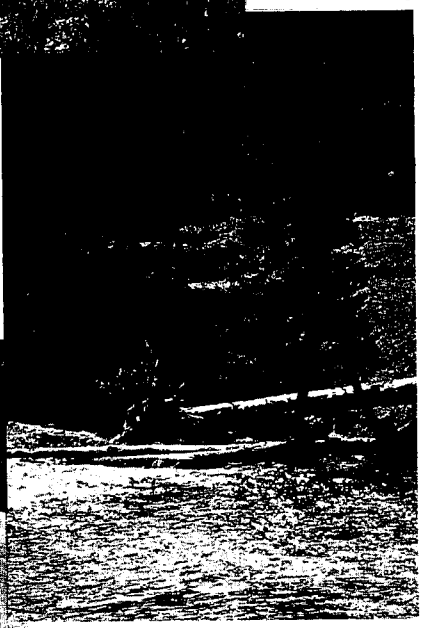

7. Spruce-fir forests yield valuable runoff for downstream water needs . . .

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8. . . . provide valuable wildlife habitat . . .

9. . . . and provide important recreational and scenic areas for the Rocky Mountain area.

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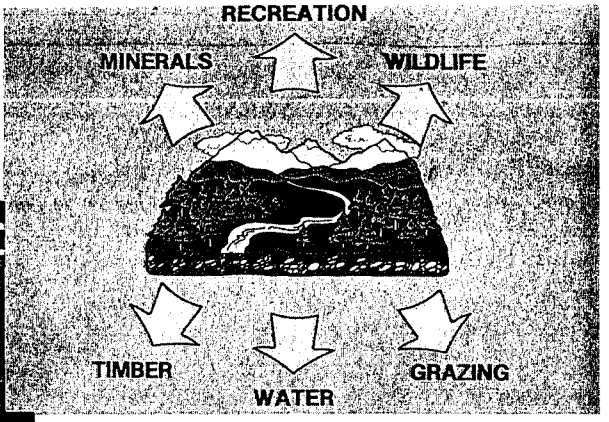

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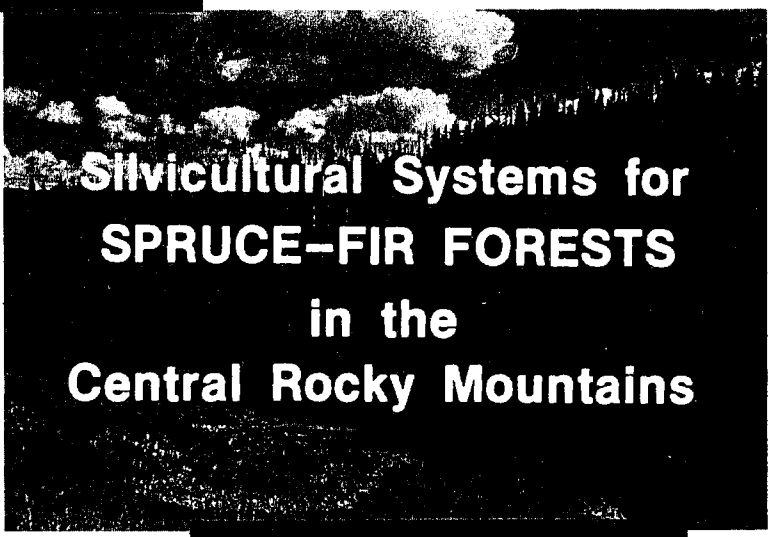

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10. Today, forest managers must manage these areas to meet increased demands for limited forest resources without serious damage to the environment.

11. This program, plus the introductory "Overview" and companion slide tapes, are designed to help you, the forest manager, make better silvicultural decisions for more productive forests.

SILVICS OF SPRUCE-FIR FORESTS

14. Throughout Colorado and Wyoming, spruce-fir forests are the principal species occurring above the 9,000 ft. elevation on north-facing slopes (Alexander, 1974) . . .

15. . . . and above 10,000 ft. they occur in solid stands.

16. Sprucè-fir forests are usually considered climax on many habitat types and are not easily displaced by other vegetation. However, drastic environmental changes caused by either fire or logging result in spruce-fir being replaced by lodgepole pine, aspen, or shrub and grass communities (Roe et. al. 1970, Stahelin 1943).

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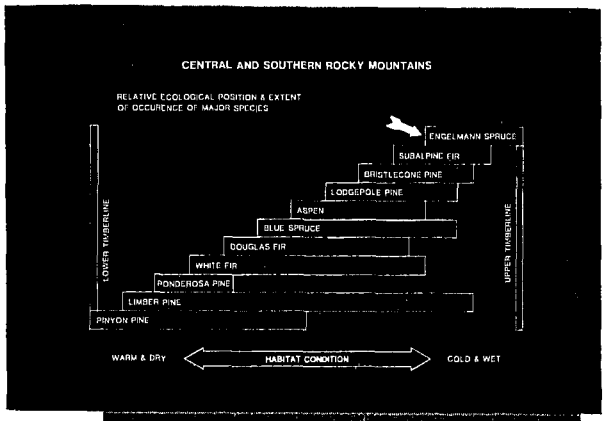

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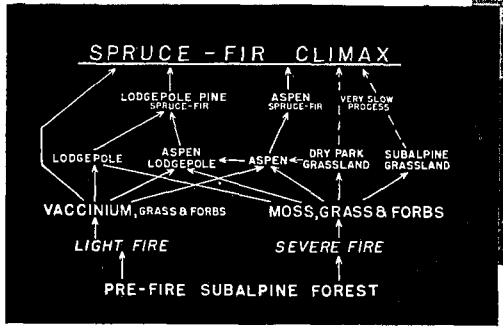

17. So far, we've taken a quick look at some environmental factors that affect the growth of spruce-fir stands. During the rest of this program, we'll take a look at various aspects of silvicultural systems that apply to this timber type. First, we'll discuss stand conditions. Then, we'll go on to factors affecting initial establishment of stands, and then to damaging agents, including wind risk, which is one of the most critical factors you'll need to understand before developing your prescriptions. Finally, we will discuss how to manage stands with reproduction established *before* cutting, versus stands with reproduction to be established *after* cutting.

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A. Stand Conditions

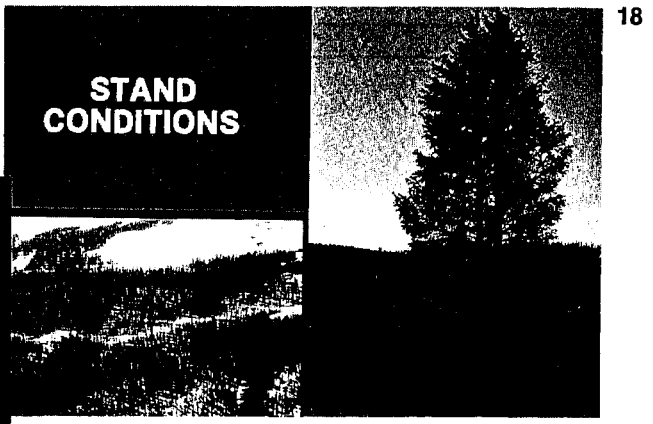
B. Initial Establishment

C. Damaging Agents

D. Management with Advanced Reproduction

E. Management with Reproduction After Cutting

STAND CONDITIONS



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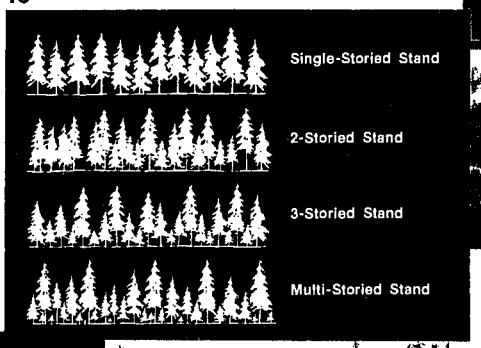

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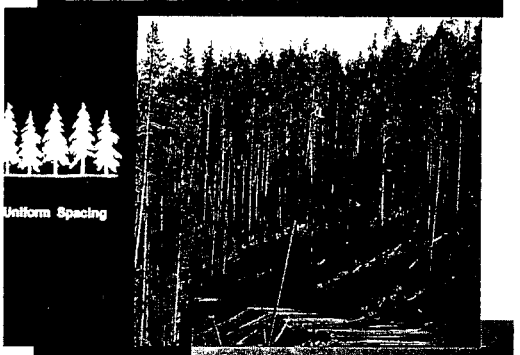

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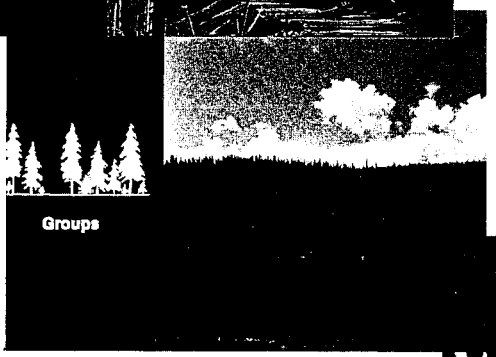

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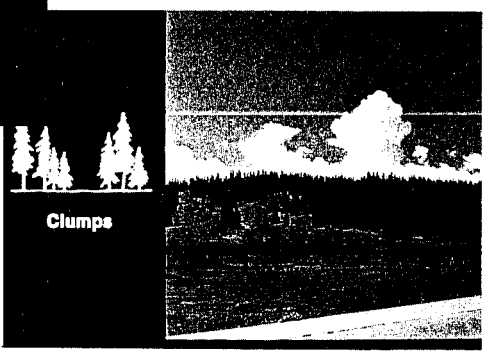

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18. Old growth spruce-fir forests grow on a wide range of sites and habitat types (Hoffman and Alexander 1976, 1980, Wirsing and Alexander 1975), with many types of stand conditions and characteristics. This diversity complicates the choice of silvicultural systems and cutting methods you can use to convert old growth to managed stands.

19. Some stands are single-storied, indicating that spruce-fir can be grown under even-aged management. Other stands are two- or three-storied, while others are multistoried, which indicate that spruce-fir can also grow in an uneven-aged condition (Alexander 1973, Whipple and Dix 1979).

20. You'll also find that trees may occur with uniform spacing . . .

21. . . . or in groups . . .

22. . . . or in clumps. (Your stand inventory should provide you with this information to consider when deciding upon a prescription for a particular stand).

INITIAL ESTABLISHMENT

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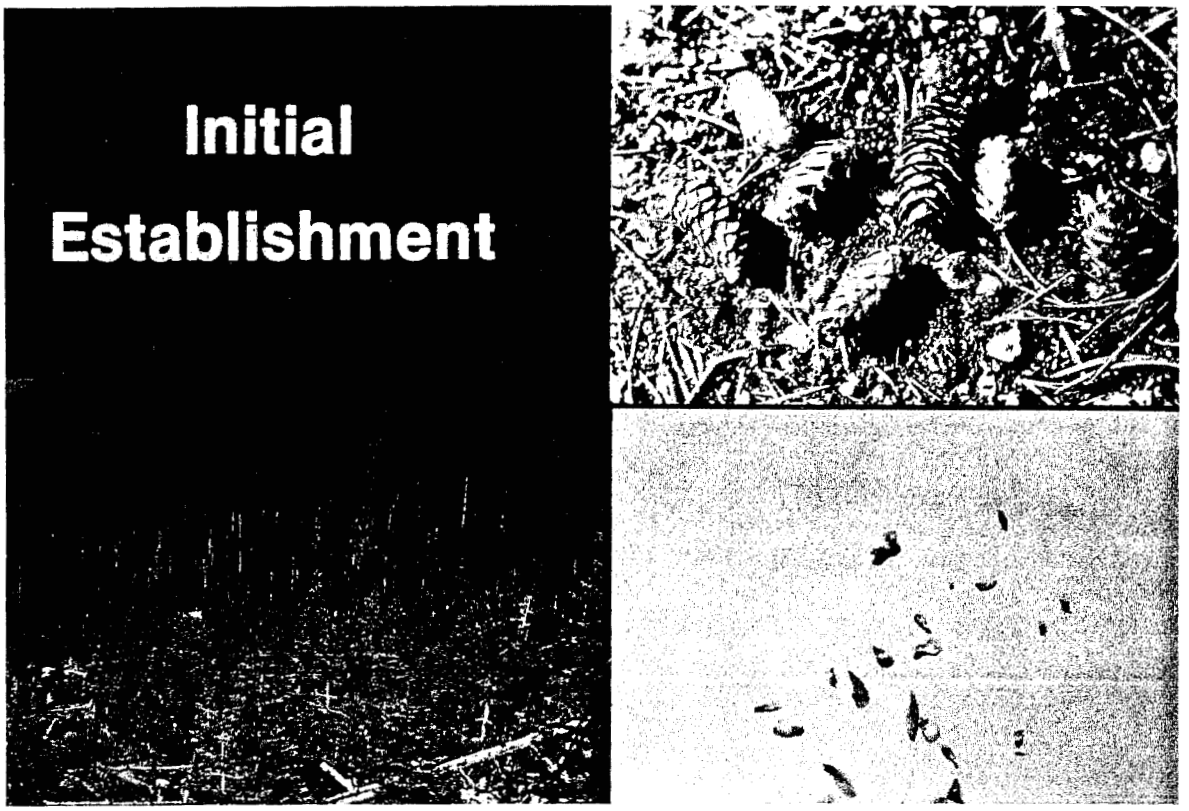
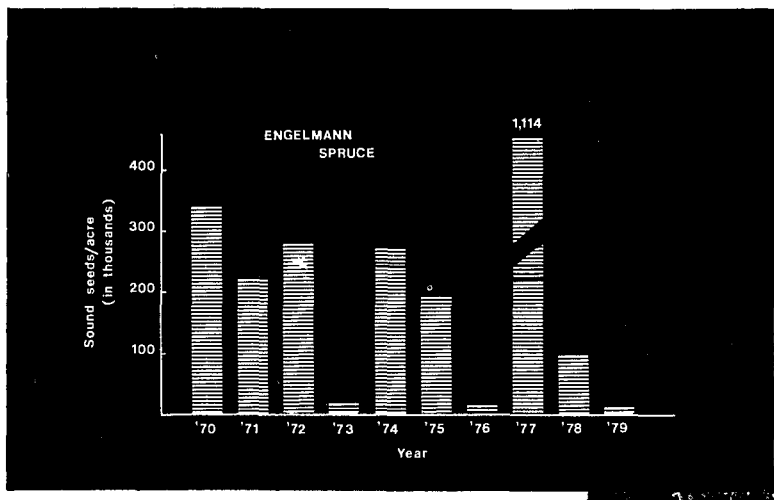


23. When you're writing a prescription, the regeneration characteristics of a species are an important part of your management plan.

SEED SOURCE



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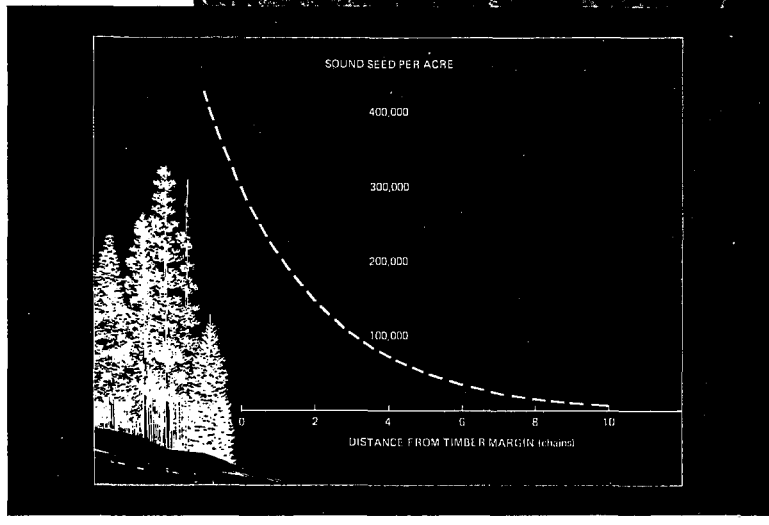
24. Engelmann spruce produces a moderate to good seed crop which varies from year to year. Seeds are light and easily dispersed by wind and gravity (Alexander 1969, Alexander et. at. 1982, Ronco 1970b, Ronco and Noble 1971).

25. Seeds that survive long, cold sub-alpine winters germinate in spring and early summer. Initial survival of seedlings is better on exposed mineral soils with organic material (Noble and Alexander 1977, Roe etal. 1970, Ronco and Noble 1971).

26. About half the seed crop falls within five to six times tree height. Beyond this, seedfall diminishes rapidly, limiting the size of openings you can use if you plan on natural regeneration.



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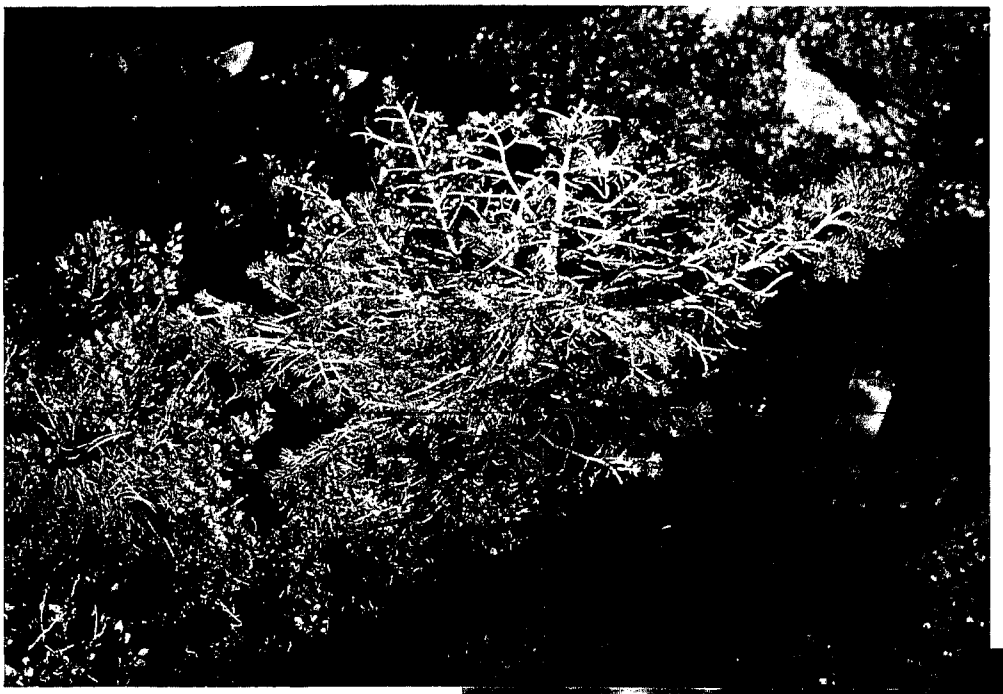

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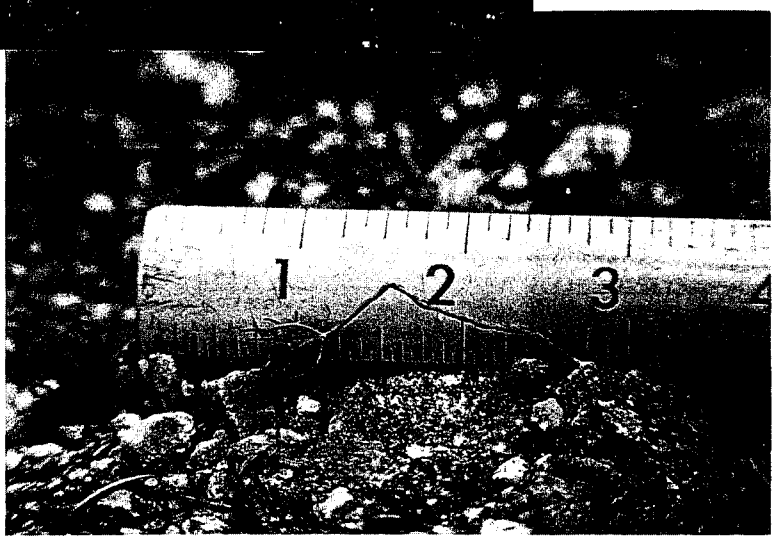

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27. Another factor to consider is sunlight. Light is essential to seedling growth and survival; however, too much light causes a condition called solarization in young spruce seedlings, and it also dries soil excessively. A certain amount of shade reduces water losses from seedlings and soil. But extremes of light or shade increase seedling mortality (Ronco 1970a, 1970c, 1970d, 1972).

28. Shade also protects seedlings from frost heaving by prolonging snow cover. This reduces the chance of daily thawing and freezing, which can be especially damaging to a shallow-rooted species such as spruce.

DAMAGING AGENTS

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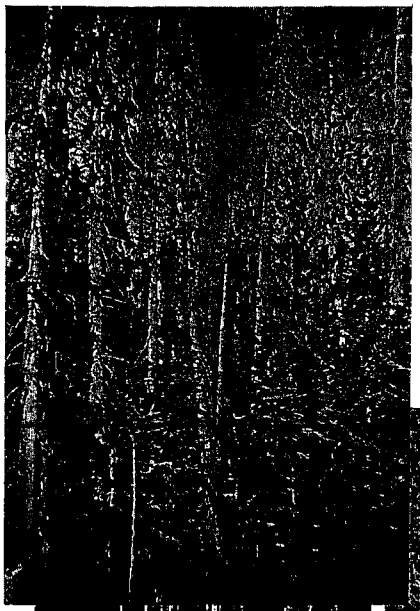
29. Insects, small mammals, birds, livestock and big game, as well as wind and disease can damage and kill seedlings and mature trees alike. Let's take a look at some of these damaging agents.

INSECTS



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30. Insect pests, especially bark beetles, are a serious problem. The spruce beetle usually attacks mature to over-mature stands (Schmid and Frye 1977).

31. Outbreaks may develop in heavy blowdown . . .

32. . . . in trees damaged by forest fires . . .

33. . . . in concentrations of large logging slash . . .

34. . . . or in stands weakened by overcrowding and defoliating insects. Once outbreak levels have reached epidemic proportions, young, vigorous trees may be killed or damaged.

35. Beetle outbreaks can best be handled by removing attacked and susceptible trees, followed by spraying or burning of all material. If there are many small diameter trees, leave them; otherwise plan to regenerate a new stand.

31

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BIRDS AND MAMMALS

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36. Squirrels and other mammals eat significant amounts of seed (Roe et al, 1970) . . .

37. . . . while voles and pocket gophers damage stems and root systems of seedlings (Crouch 1982).

38. Small birds such as juncos clip off new growth (Noble and Shepperd 1973). . . .

39. . . . and big game animals and sheep browse and trample young seedlings (Roe et al 1970).

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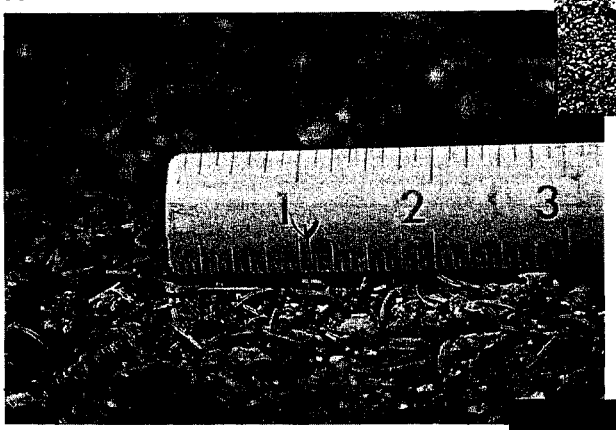

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DISEASES

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40. Older trees are often infected by wood rotting fungi and broom rusts. These diseases cause a loss in volume, reduce growth, and increase susceptibility to windthrow and windbreak (Hinds 1977, Hinds and Hawksworth 1966).

ORGANIC MATERIAL

41

41. Even dense grass stands and other organic material can kill young seedlings. Grass, if thick enough, smothers seedlings and robs them of soil moisture.

WIND

42

43

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42. Wind in high elevations is often damaging to spruce-fir forests. Wind risk can also be related to stand conditions, cutting methods, soil depth and drainage, and topographic exposure. There are several topographic criteria that can help you determine the wind risk of a particular stand (Alexander 1964). For example, . . .

43. . . . In this slide, south or west faces to the left, and north or east to the right. Wind risk is high on all ridge tops. It is high on south and west-facing upper and mid-slopes that are moderate to steep, as shown by the left side of the large mountain here.

44. Wind risk is usually moderate in situations at the mid-slope range, on moderate to steep slopes that face south or west but are *protected* by higher ground, such as the smaller ridge which we see here to the left. It is moderate on steep middle slopes and upper slopes which face north or east, primarily the belt that is shown between the high line and the medium line on this slide.

45. Wind risk is low, or below average in three different cases: The first is in flat areas or valley bottoms at right angles to the wind; secondly on both lower slopes AND gentle slopes that face north or east, as shown toward the right in this slide; and finally, on lower slopes and gentle middle slopes that face south and west, as toward the left in the slide, that are protected by higher ground close to the windward side.

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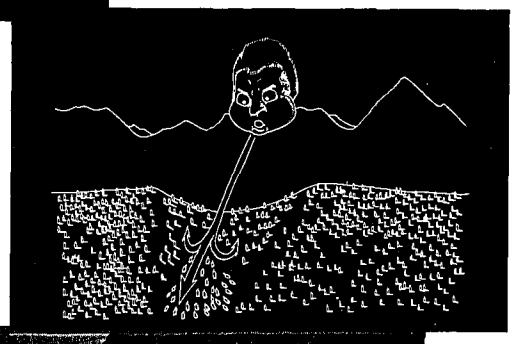

46. Wind risk can also be high in the valley bottoms which are parallel to the wind, as shown here; and can also be high . . .

47. . . . in areas where wind is funneled through saddles and ridges as shown by this slide.

48. Remember, wind risk is important when marking for management.

49. Occasionally, tree crowns are intertwined and protect one another from wind. If trees are paired, both can be left standing . . .

50. . . . both can be cut, or if wind direction is definitely known and they are not too close together, the tree on the leeward side can be removed, provided it's shorter.

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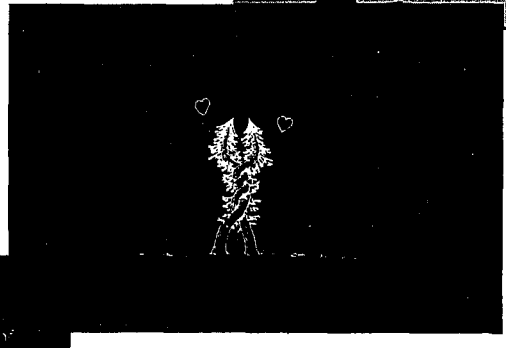

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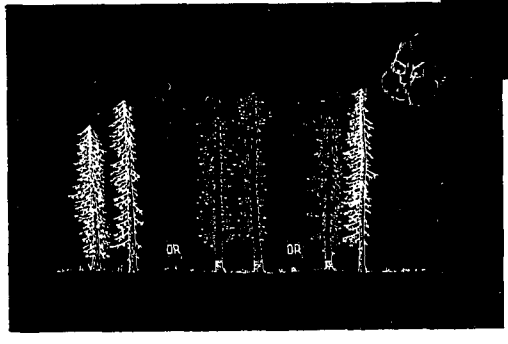

51. However, this *may* be a calculated risk. Often when one tree of a pair is removed, wind is likely to blow the other down even in low wind risk areas.

52. You have two options for trees occurring in clumps or groups.

53. Either leave all trees standing, as shown to the left; or remove all trees, as shown in the center.

54. Occasionally, smaller trees can be removed from the leeward side of the clump. However, do this only where you definitely know the direction of prevailing winds and never in a high risk situation.

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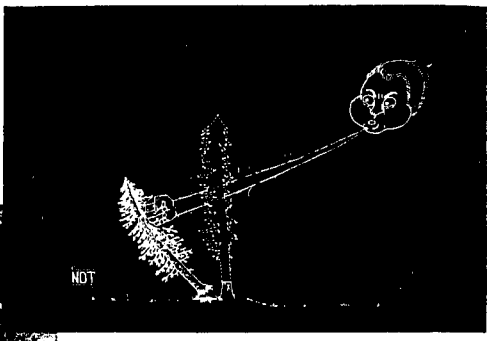

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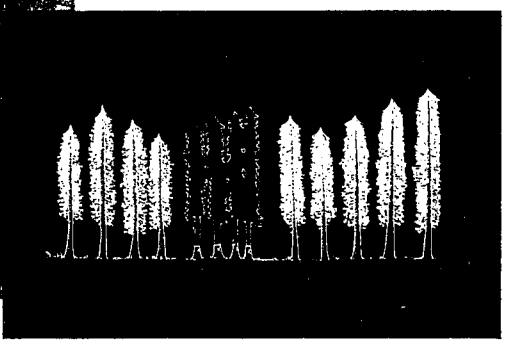

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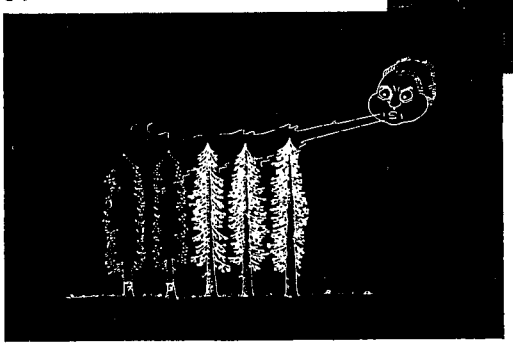

- **Environmental Factors**
- **Stand Conditions**
- **Initial Establishment**
- **Damaging Agents**

55

55. Up to this point, we've discussed some of the silvicultural aspects of spruce-fir stands. We've looked at:

- Environmental factors
- Stand conditions
- Initial establishment, and,
- Damaging agents

Before we launch into the last two major sections of this talk, let's review some generalities of regeneration silviculture (Alexander 1974).

REVIEW OF REGENERATION SILVICULTURE

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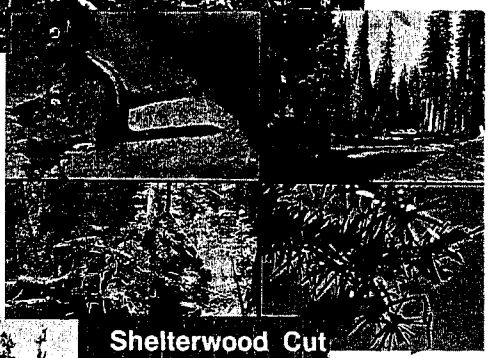

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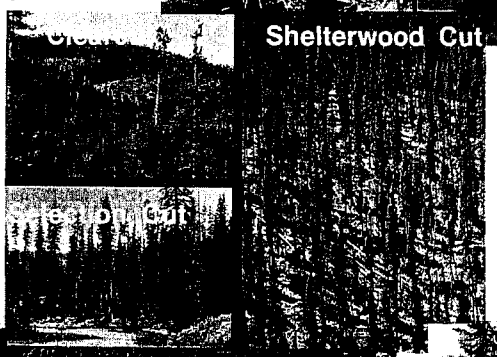

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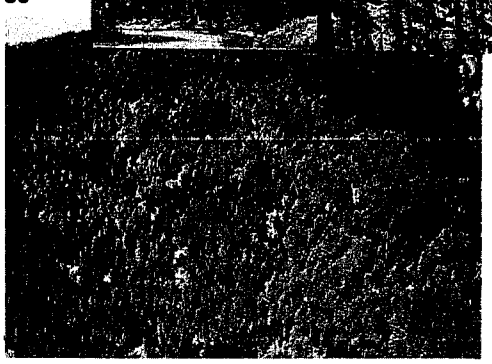

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56. As you'll remember from the overview slide-tape, the objective of regeneration systems is to harvest the timber crop and obtain adequate reproduction. Your choice of cutting method will depend on management objectives and environmental conditions, . . .

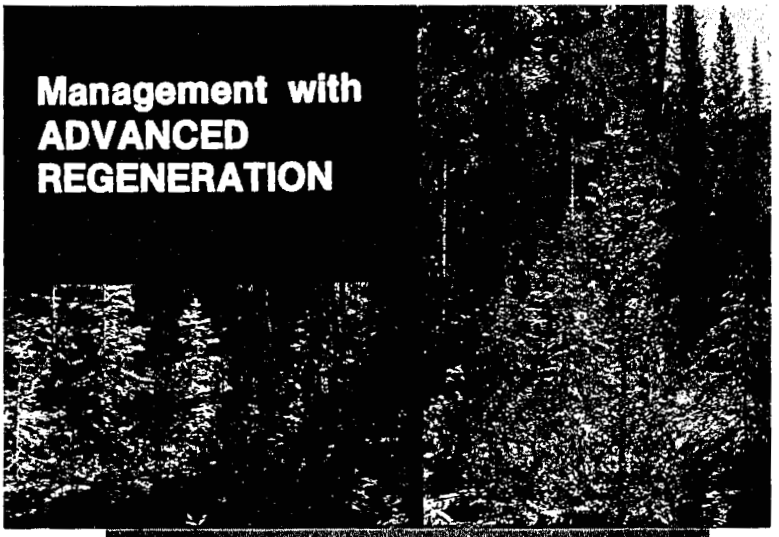
57. . . . but you'll also need to consider stand conditions, regeneration problems, windfall risk, and disease and insect susceptibility, all of which vary from place to place.

58. Those cutting methods that apply to spruce-fir forests include clearcutting and shelterwood and selection cutting and their modifications.

59. You should *not* use partial cutting in *high* wind risk situations, *or* in stands where spruce beetle infestations are building up.

60. You'll find on many areas that a prescription to bring old-growth spruce-fir under management is likely to involve a combination of several cutting treatments. To restock these cutovers, you should first consider cultivating existing advanced reproduction shown here, and secondly, restocking after cutting by natural or artificial means.

MANAGEMENT WITH ADVANCED REGENERATION



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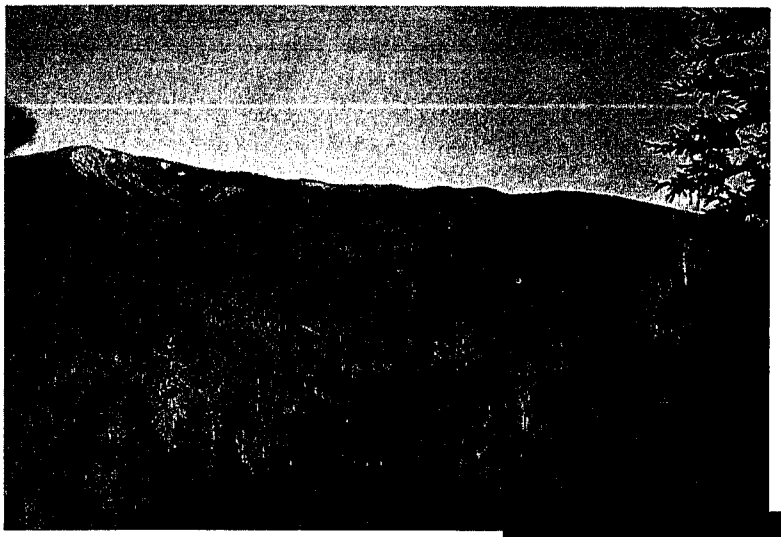
63

61. Let's look at the first of the two situations. Many spruce-fir stands have an existing stand of advanced growth.

62. However, because of variations in age, composition, quality and quantity of advanced reproduction, you must carefully evaluate its potential for future management before harvesting begins. You'll need to follow one course of action if advanced reproduction is to be managed, another if it is not.

63. In addition, you must reevaluate the stand after the final harvest and slash disposal to determine whether it needs supplemental stocking.



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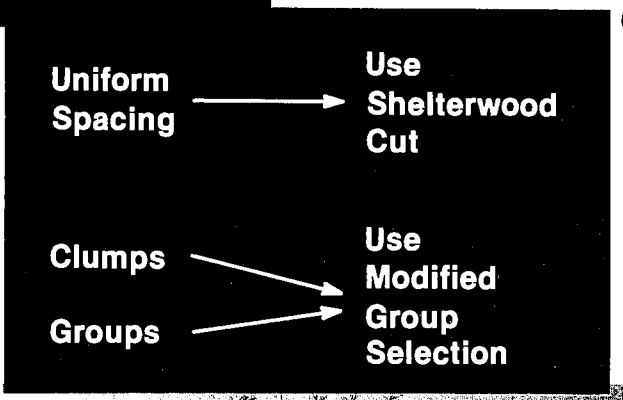
64. Where you will utilize advance regeneration, the size, shape, and arrangement of openings are not critical from a regeneration standpoint, but they must be compatible with other key uses. Where water yield is a key consideration, openings should not be greater than about 5 to 8 times tree height. They should also be irregular in shape, and blend into the landscape.



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65. You should use simulated shelterwood cutting where trees are uniformly spaced, and a modified group selection where they are clumpy, groupy or patchy. Regardless of stand structure, you may need to remove the overstory *in more than one step.* The amount of basal area that can be removed at each entry, the number of entries, and the size of group openings is determined by stand characteristics and windfall risk.

66. In recreation or other multiple-use areas where your objectives include maintaining mature forests, individual tree selection is appropriate.

66

MANAGEMENT WITH REPRODUCTION AFTER CUTTING

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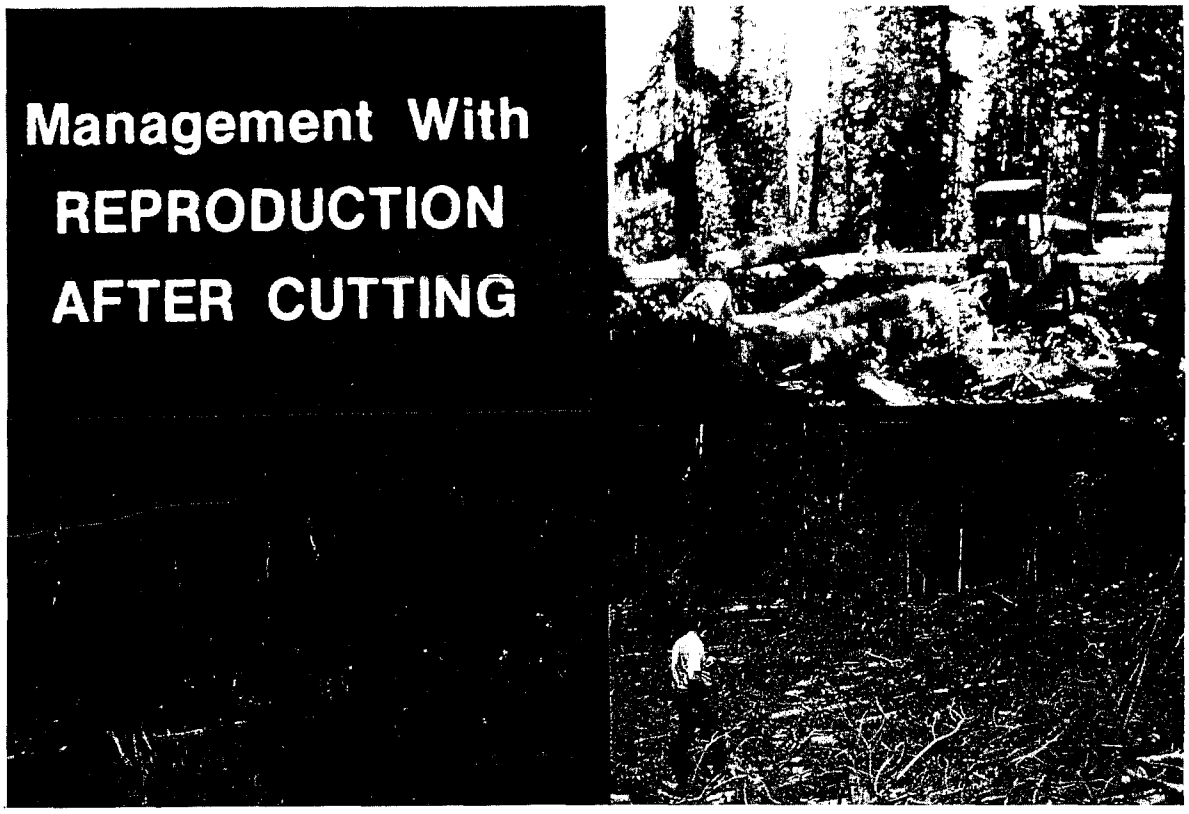

67. For spruce-fir, the second (and more complex) of the two situations in regeneration silviculture is management with reproduction *after* cutting. This is possible on both clearcut and partial cut areas.

ESSENTIAL ELEMENTS OF REGENERATION

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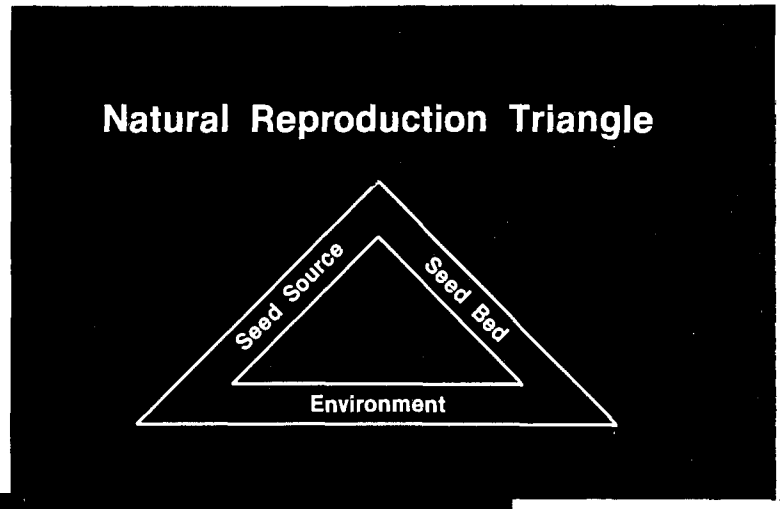
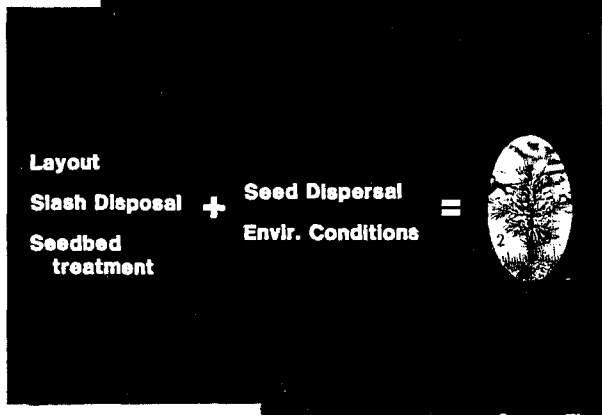


68. In *both* instances, we need to be very concerned with providing the three interdependent elements of the regeneration triangle we discussed in the overview slide tape (Roe et al. 1970). You'll remember that successful regeneration of any species is dependent upon a suitable supply of seed, a suitable seed bed for germination, and a suitable environment for germination and survival. Let's look at the ways that these three elements apply to clear-cutting.

69



69. On clear-cut units in spruce-fir type, the layout of the unit, slash disposal, and seed bed treatment all need to be designed to facilitate seed dispersal and to create good conditions for germination and seedling establishment.

70. Remember that the size of the openings you clearcut in spruce-fir is dependent upon seed dispersal. The cutting unit must be designed so that seed from the trees bordering the clearcut can reach all portions of the openings. This is usually an area no longer than about five to six times tree height (Alexander 1974, Roe et. al. 1970)

Spruce-Fir

The estimated maximum distance that can be seeded from all sides and size of opening that can be made on the two aspects based on moderate to good seed production is:

Seedbed and Aspect	Maximum Distance That Can Be Seeded (ft)	Maximum Size Opening (Tree Heights)
Shaded, Mineral Soil:		
North	450-500	5-6
South	150-200	2-2½
Unshaded, Natural:		
North	50-100	1-1½
South	0	0

70

71

NATURAL REGENERATION ENVIRONMENTS

FAVORABLE	UNFAVORABLE
North aspect	South aspect
40–60% shade	<10% shade
50% bare soil	<10% bare soil
1.5cm rain/wk.	<1.5cm rain/wk.
Temperature °C	Temperature °C
Day air <25	Day air >25
Night air >0	Night air <0
Soil surf. <35	Soil surf. >50

72

73

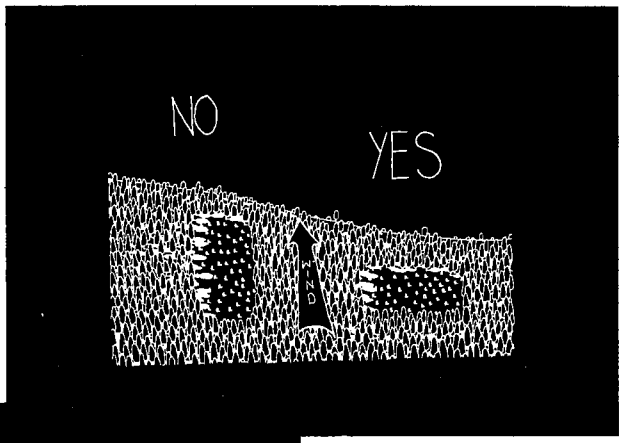
71. The environment you provide through site preparation is also critical to seedling survival. The unit must be located on aspects which will provide an adequate environment for seed germination and establishment. Research studies have shown that the most favorable environments for clear-cutting Engelmann spruce and subalpine fir are on north aspects, which are partially shaded with at least 50% bare soil. North aspects also provide soil surface temperatures which are much more favorable to germination and survival than those on south aspects (Noble and Alexander 1977).

72. Clearcutting spruce-fir on south and west aspects is often less successful because of their extreme environmental conditions and the long period of time it takes to establish reproduction on such sites.

73. It's not likely that a clearcut on a south slope could result in acceptable stands of new reproduction within a reasonable period of time without fill-in planting.

CLEARCUTTING

74



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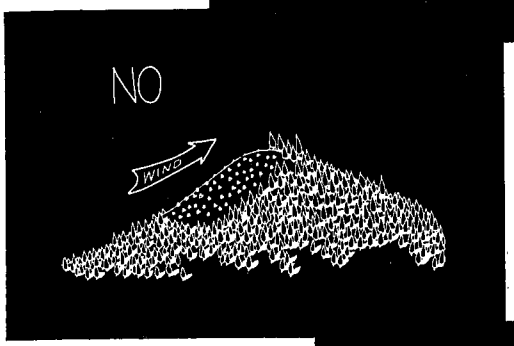
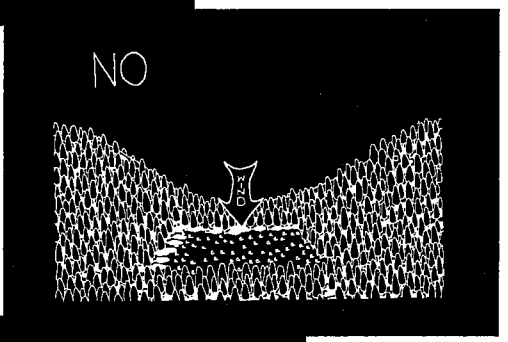
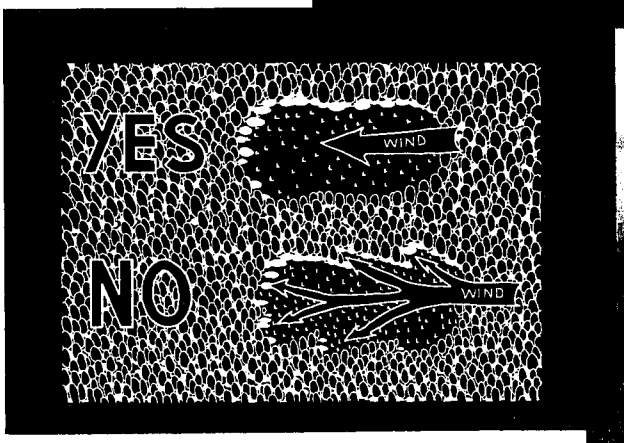






77

74. You also need to be aware of wind patterns when you are laying out a clearcut in spruce-fir type (Alexander 1964, 1967, 1974). You should avoid laying out clearcuts which run up slopes parallel with the direction of the wind, as shown on the left of this slide; but rather should try to lay them out across the slope, exposed where the short dimension of the clearcut block would be exposed to the wind as we see on the right.

75. You should also avoid laying out clearcut blocks on ridge tops, . . .

76. . . . or directly below saddles where wind vortexing often occurs and increases blowdown risk.

77. Irregular cutting boundaries without sharp indentations or square corners also help reduce blowdown.

78. Avoid poorly drained or shallow soil along the edges of the boundaries of the clearcut. Boundaries should be placed in stands of sound trees or in immature stands or poorly stocked stands which naturally are more windfirm.

76

78

PARTIAL CUTTING

79

79. Now, let's look at partial cutting techniques used to regenerate an old-growth spruce-fir stand (Alexander 1973). In order to regenerate the stand, the objective of these cuts is to leave either an overstory canopy, or trees standing around the margins of small openings to provide an effective seed source. They also provide an environment compatible with germination, initial survival, and seedling establishment. But *you* must make sure that . . .

80. . . . a suitable seedbed is provided after the seed cut where shelterwood cutting is used, and after each cut where group selection is used.

80

81

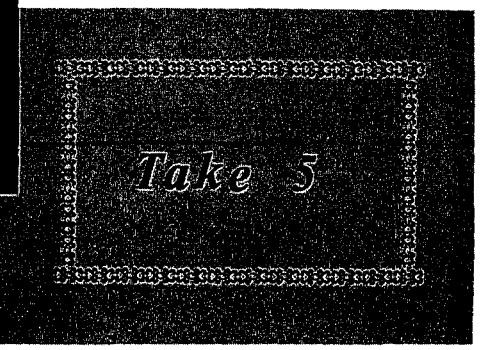
Partial Cut Areas

Regeneration by New Reproduction

Key Factors

1. Structure
2. Windrisk
3. Distribution

82



81. All of this sounds simple enough in theory; but three key factors need to be considered before prescribing a partial cutting treatment: structure, wind risk, and distribution. Each of these three factors has a hand in determining which silvicultural system and cutting method you should use, how the stand should be marked, and when to schedule subsequent entries.

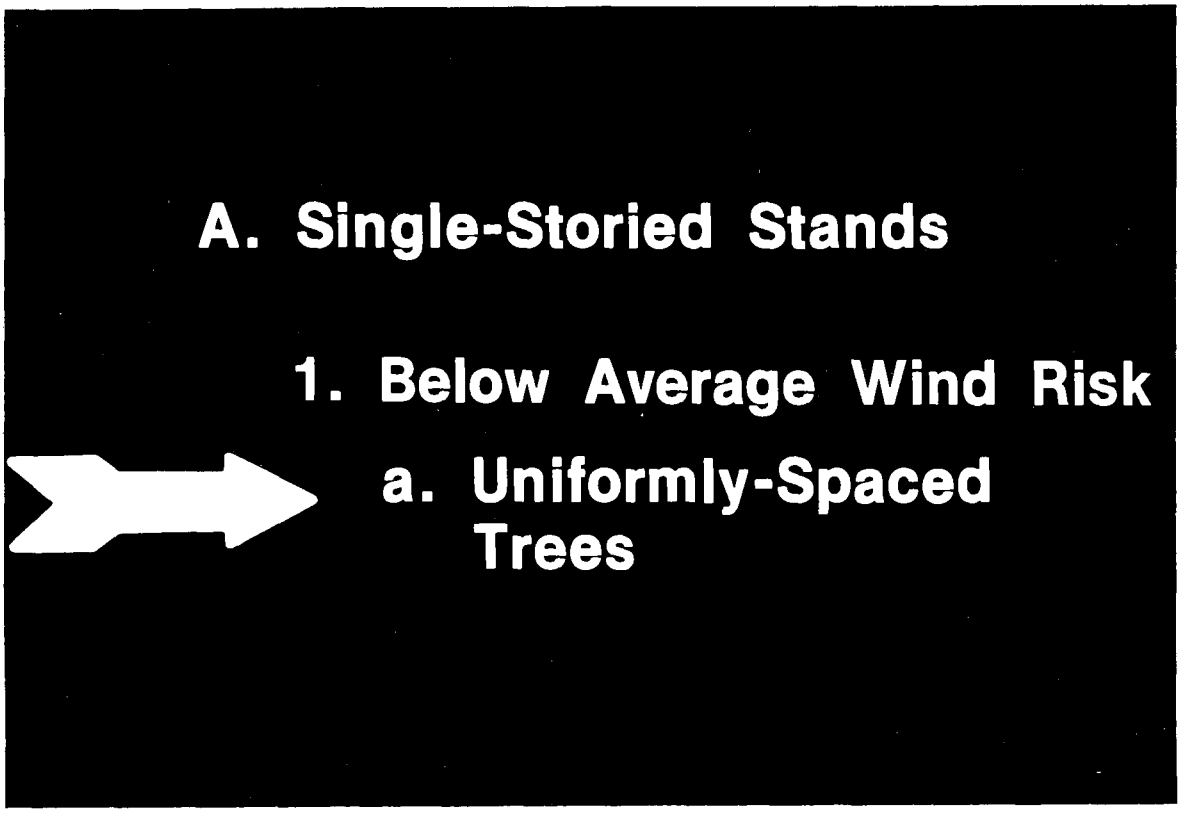
82. Because this is such a complex subject, this is a good time for you to take a stretch break before we launch into a more detailed description of the effects of these 3 factors on your management of spruce-fir stands.

83. Remember, we're still talking about managing with reproduction *after* cutting. From this point on, things get pretty complex. We're going to be discussing the three key factors of structure, wind risk, and tree distribution. To help keep things straight, we'll split our discussion into three sections. We'll first cover single-storied stands, presenting techniques to use for uniformly-spaced stands vs. clumps or groups that occur in different wind risk situations. We'll then follow the same procedure for two- to three-storied stands, and finally for multistoried stands.

- Single-Storied Stands
- 2 & 3-Storied Stands
- Multi-Storied Stands

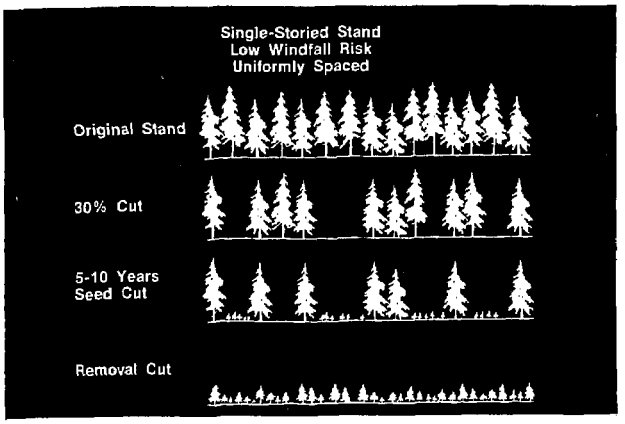
83

84



84. First, let's look at single-storied stands. These stands are usually the least windfirm, because trees are relatively the same height, have developed together over a period of time, and mutually protect one another from the wind. We must therefore *gradually* open the stand up to develop windfirmness before establishing a regeneration cut. The relative wind risk of a stand and the spacing of the trees have a good deal to do with the prescription which is developed for an area. Where windfall risk is below average and the trees are uniformly spaced, we can first make an initial cut . . .

Below-Average Windrisk . . . Uniformly-Spaced Stands



85-87

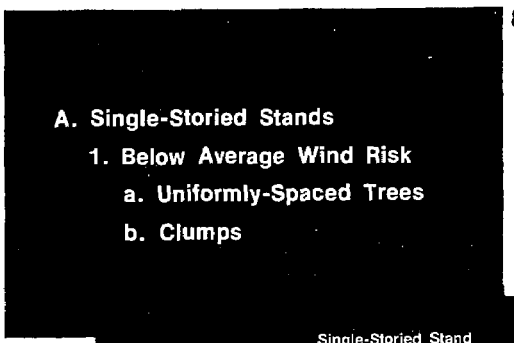
85. . . . that removes about 30 percent of the basal area. Since all over-story trees are about equally susceptable to windthrow, we need to maintain the general level of the canopy by removing some trees from each overstory crown class, as we have done in this first cut in the example.

86. The second cut, or seed cut, which will begin to regenerate the stand, follows in approximately five or ten years. Here we remove a similar volume for the first cut, and we don't make a third cut until the regeneration is well established. Once the regeneration is established the . . .

87. . . . third cut may or may not remove all the remaining overstory. Trees held for the fourth cut, if it is needed, will provide an additional period of protection for the regeneration to become established.

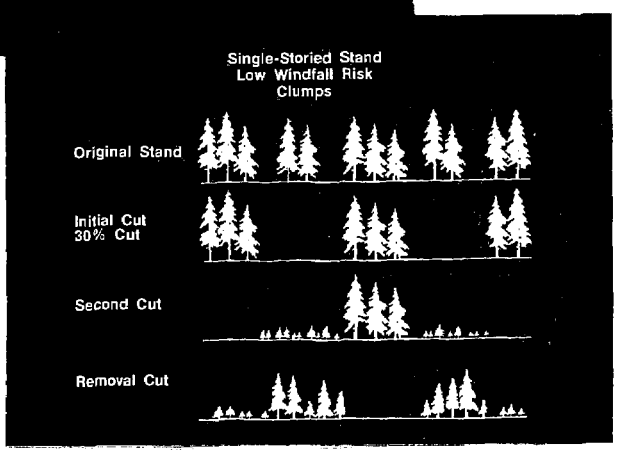
Below-Average Windrisk . . . Clumpy Stands

88. Now then, in single storied stands with a low wind risk which are clumpy in nature, the first cut should . . .



88

89-90



89. . . . be in groups that remove about 30 percent of the basal area. Harvesting timber in groups this way takes advantage of the natural arrangement of trees. The group openings should not be more than one, or at most two, tree heights in diameter; and not more than one-third of the area should be cut at any one time. The cuts should be spaced fairly uniformly throughout the stand, based on the structure of the groups as you see here.

90. There should be at least two more cuts. They can enlarge openings by approximately one tree height, after each original opening has been regenerated, by cutting adjacent clumps, as we see here in the second and third cuts. You should cut new openings no closer than one to two tree heights from openings not yet regenerated. In other words, this is a sequential process that progresses through the grouped stands.

Above-Average Windrisk . . . Uniformly-Spaced Stands

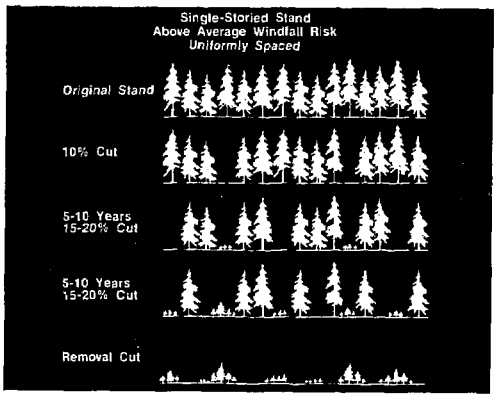
91

A. Single-Storied Stands
   1. Below Average Wind Risk
      a. Uniformly-Spaced Trees
      b. Clumps
   2. Above Average Wind Risk
      a. Uniformly-Spaced Trees

91. Let's move on now, and look at another situation that you can have in single-storied stands — that being on sites with above average wind risk, but with a uniformly spaced stand. In this case we have two alternatives by which we can handle the stand. The first alternative . . .

. . . Alternative I

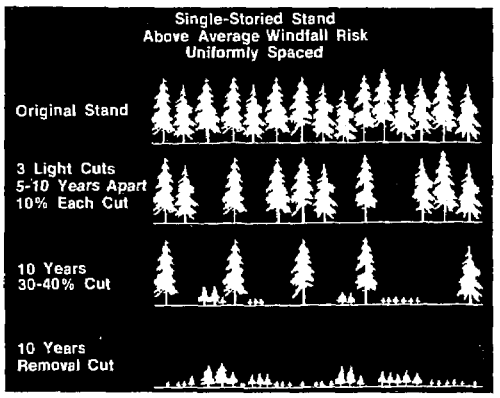
92-93



92. . . . removes about 10% of the basal area in the initial cut on an individual tree basis. This is a very light cut. It opens the stand just enough to allow remaining trees to begin to become wind firm. This method resembles a sanitation cut, in that the poorest risk trees are removed to maintain the general level of the overstory canopy.

93. Two additional light cuts, each of which removes about 15 to 20% of the basal area at five or ten year intervals, should then condition the stand for a final removal cut, which harvests the remaining overstory. However, the final harvest should not be made until a manageable stand of reproduction is established.

. . . Alternative II



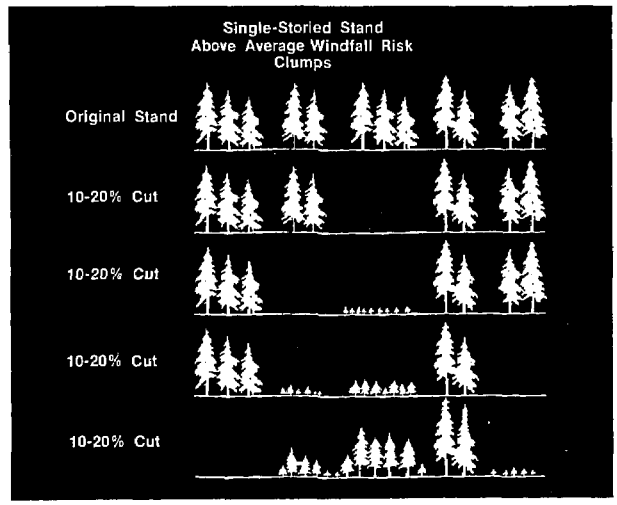
30 94-95

94. The second alternative is a little different. It removes about 10% of the basal area in each of a series of three light cuts at five to ten year intervals. Again, this is done to condition the stand for resistance to windthrow.

95. The remaining 70% of the basal area in this alternative, however, is removed in two cuts that take 30 to 40% of the basal area each. The last two cuts are usually spaced at approximately ten year intervals. This method is somewhat risky in that it increases the risk of blowdown, as we see in the final stand on this slide. But it does encourage better stand reproduction, because you are opening the stand up more rapidly.

Above-Average Windrisk . . . Clumpy Stands

96



96. Moving on to single-storied clumped stands in an above average wind risk situation, the best procedure is a series of light cuts, removing 10 to 20% of the basal area in groups. But, remember, again, the entire group should either be cut or left.

High Windrisk Or Stands Breaking Up

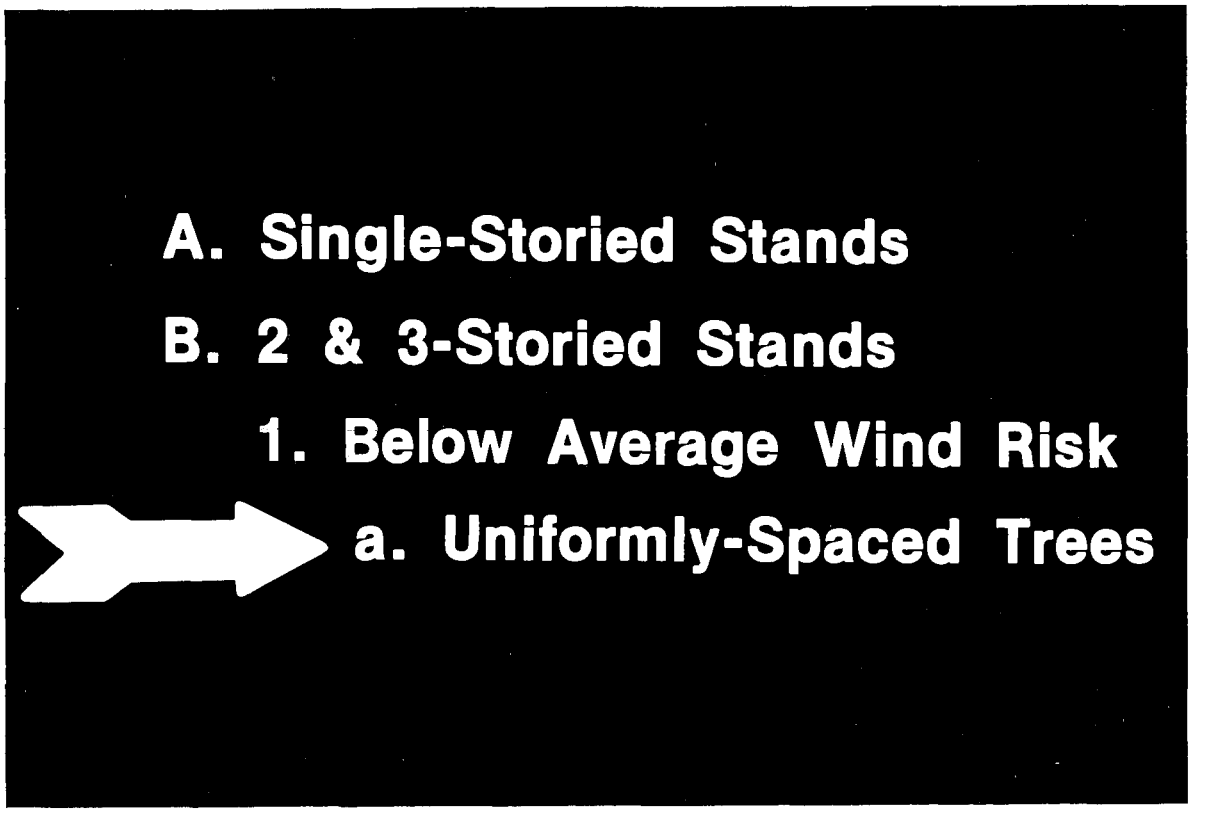
97

A. Single-Storied Stands
   1. Below Average Wind Risk
      a. Uniformly-Spaced Trees
      b. Clumps
   2. Above Average Wind Risk
      a. Uniformly-Spaced Trees
      b. Clumps
   3. Very High Wind Risk,
      or Stands Breaking Up

97. In single-storied stands that either occur in very high wind risk situations, or that are breaking up due to windthrow, you are usually limited to the removal of all trees, or leaving the stand uncut.

Two And Three Storied Stands

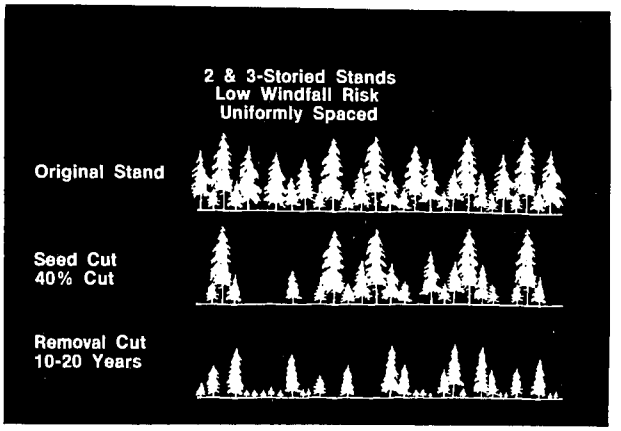
98



98. We will now move on to two- and three-storied stands. Cutting methods for two- or three-storied stands differ somewhat from single-storied stands in that the overstory of two- or three-storied stands may be windfirm, but the second and third stories are likely to be susceptible to windfall. In stands like these where windfall risk is below average and the trees are uniformly spaced, . . .

Below-Average Windrisk . . . Uniformly Spaced Stands

99. . . . the first cut can remove up to 40 percent of the basal area. However, openings in the canopy should not be larger than one tree height in diameter, or should be cut over the entire area. This is very similar to the first step, or seed cut, of a two cut shelterwood; but trees are removed from each diameter class. Since the overstory is likely to be more windfirm, leave the dominant and codominant trees in the interior of the stand as protection for trees that are saved until the following cut. Dominants and codominants are also good seed sources.



99-100

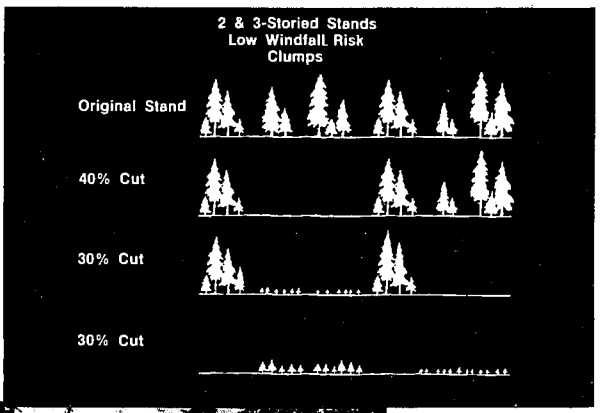
100. The second cut, usually occuring in ten or twenty years, removes the remaining overstory and encourages a subsequent growth of the reproduction. This is essentially a two-cut shelterwood.

Below-Average Windrisk . . . Clumpy Stands

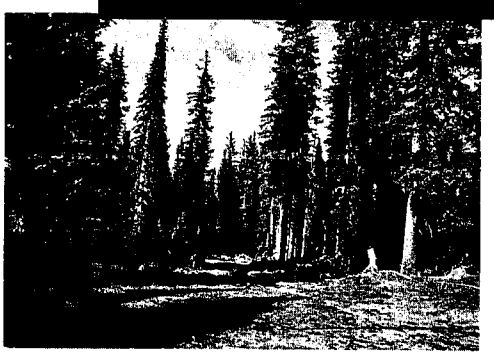
101. If the windfall risk in a two or three storied stand is below average and the trees are in clumps, the first cut should remove 40 percent of the basal area in groups. Group openings can be larger in this case, . . .

102. . . . up to two or three times tree height, than for single-storied stands, but do not cut more than one-third of the total land area. Make group openings irregular in shape, but without dangerous windcatching indentations. Again, the entire clump should either be cut or left.

103. A second or third cut in these situations can remove approximately 30 percent of the original basal area in group openings, with openings two to three times tree height. With a two to three storied stand, you usually have a little more choice of which groups you can take; and you can usually cut it a little more quickly than you would with a single-storied situation. It becomes somewhat easier operationally on the ground.



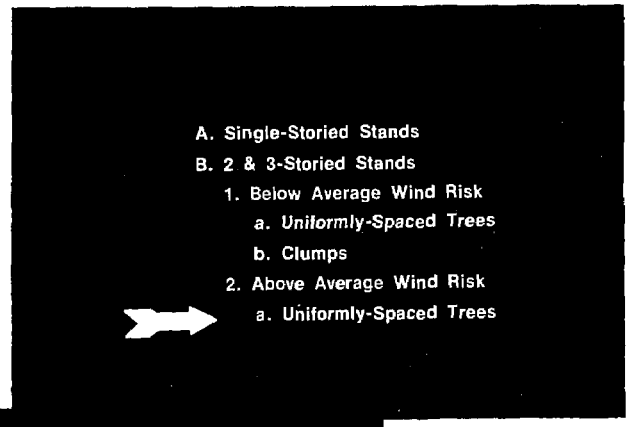
101 & 103



102

Above-Average Windrisk . . . Uniformly-Spaced Stands

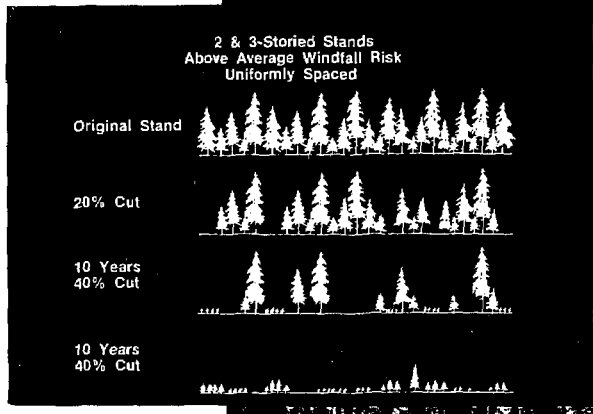
104



104. Two or three storied, uniformly spaced stands will also occur in above-average windfall risk situations. In such cases, the . . .

105. . . . first cut should be light, which will prepare the stand for additional cuts. In this cut, you can remove up to 20 percent of the basal area on an individual tree basis. Again, in this situation you should try to maintain the general level of the canopy, but can remove predominants, intermediates with dense crowns, and trees with indications of defect. As we've said before, we have more opportunity to sanitize the stand in a two- or three-storied situation.

106. The objective is to open up the stand and minimize windfall risk to trees left standing. However, plan to salvage windfalls if they do happen. In situations like this, you should pay close attention to the individual tree wind marking rules presented in the overview talk.

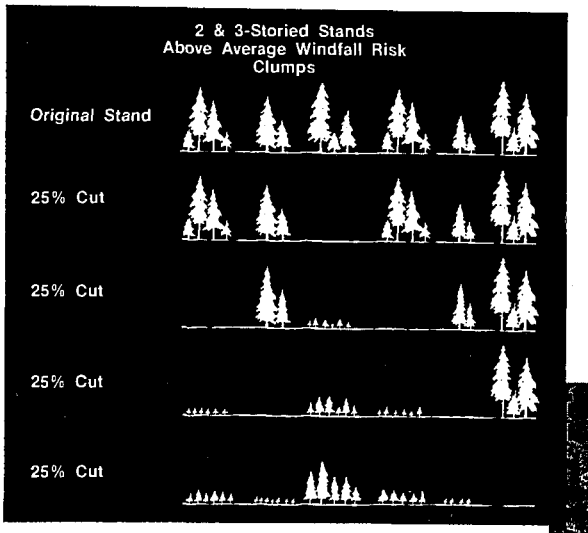


105 & 107

107. At least two additional entries at about 10 year intervals will remove the remaining overstory.

106

Above-Average Windrisk . . . Clumpy Stands



108 & 110

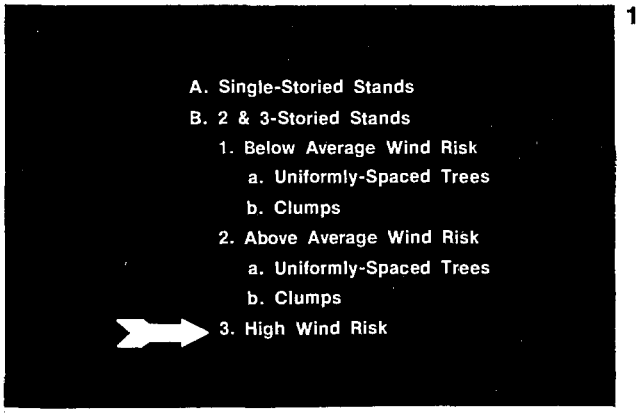
108. In situations where we have an above average windfall risk in two- and three-storied stands, and the stands are clumpy, we can remove about 25 percent of the basal area, again marking by groups as we have done previously.

109

109. In this case, we need to keep the group openings small, not more than one to two tree heights in diameter. Also, not more than one-fourth of the area should be cut over at any one time. The reason for this is that we're in a high windfall risk situation. We want to avoid larger openings, and we want to take a smaller percentage of the total basal area of the entire stand in the first entry.

110. Three additional entries may be needed to remove all the original stand and completely regenerate the area.

High Windrisk

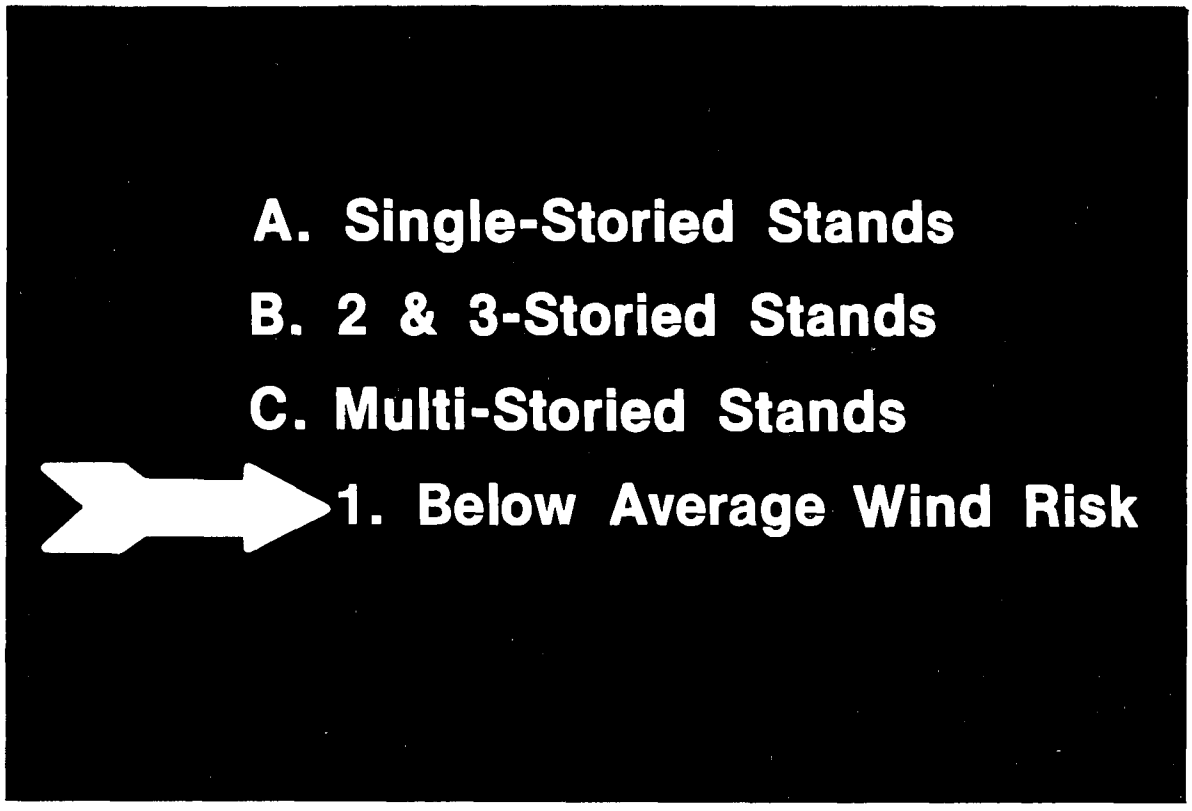


111

111. Where windfall hazards are very high, you are again limited to removing all trees or leaving the area uncut. Cleared openings should not be larger than regeneration requirements dictate, that is, no more than five to six times tree height. They should be intersperced with uncut areas. If the cut is made, not more than one-third of the area should be cut at any one time.

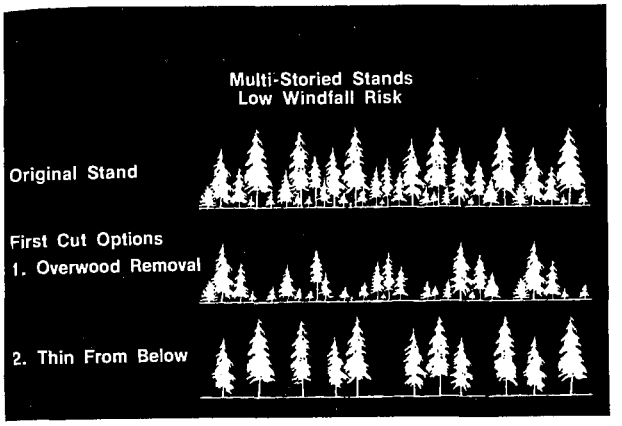
Multistoried Stands

112



112. Now, let's move on to multi-storied stands. Multi-storied stands are usually the most windfirm, even where they have developed from deterioration of single-storied stands. There is considerable flexibility in harvesting methods where windfall risk is below average in these situations. All stands and classes can be cut, with emphasis on either the largest or the smallest trees, as the management needs indicate.

Below-Average Windrisk



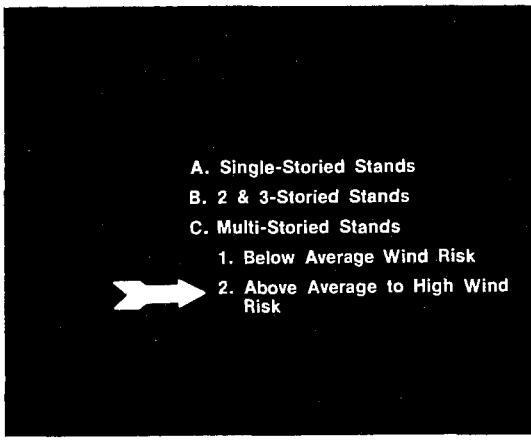
113 & 114

113. For example, the first cut can remove all the large trees in the overstory, to encourage younger growing stock; or the trees can be thinned from below, to improve the spacing of the larger trees. If you decide on overstory removal, as shown in this example, and if the volume is too heavy, do it in two entries. The reason for this is that if the overstory volume is too great, it is impossible to log the area without destroying the smaller trees below. Additional cuttings can be directed towards either even- or uneven-aged management, as resource needs of the stand indicate.

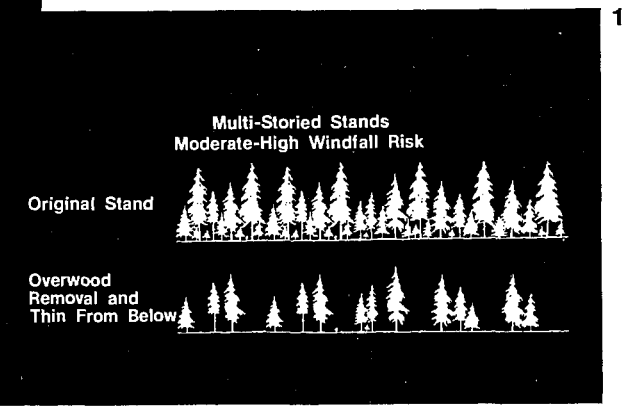
114. A thinning from below, as shown in this example, would usually be used if the management of the stand was being directed towards even-aged management; while the overwood removal, depending upon the resulting stand structure of the remaining understory, could either be directed towards uneven-aged management or even-aged management.

Above-Average To High Windrisk

115



116



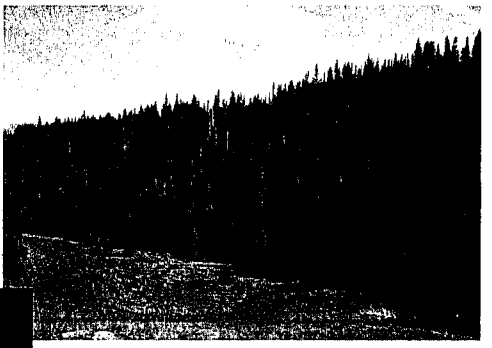
115. In multi-storied stands, where wind risk is above average or very high, the primary concern is to use a cutting method that will develop windfirmness. The safest first-cut is an overwood removal, . . .

116. . . . in combination with a thinning from below to obtain a widely spaced, open grown stand which can then be directed towards either even- or uneven-aged management. Again, it depends upon the resulting stand structure. In situations such as these, you need to be extremely careful in marking the trees to select leave-trees which are windfirm and not likely to blow down. Otherwise the entire stand could be lost.

CONCLUSION

117. It is obvious from what we have seen that spruce-fir forests in the Central Rockies are very complex. They require a great deal of consideration to arrive at a proper silvicultural prescription to bring old growth stands under management.

118. There are many operations crucial to successful silvicultural treatments. A breakdown or failure of any will result in the failure of the entire process.



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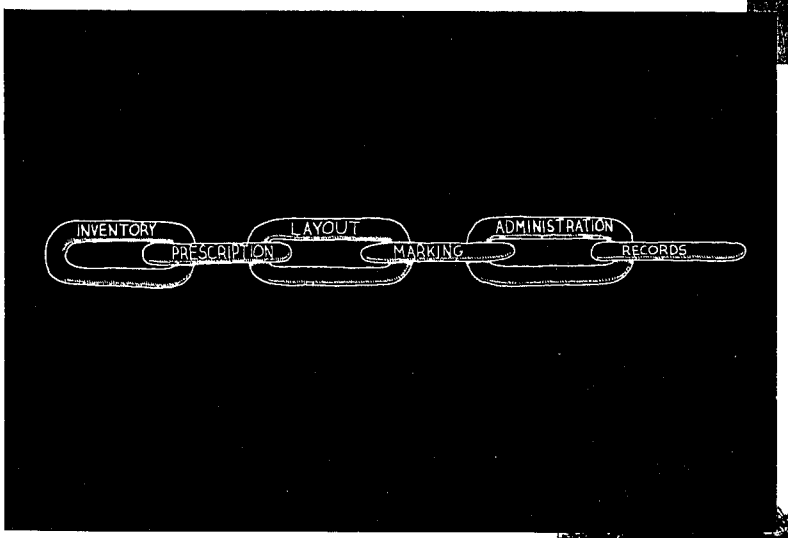


118

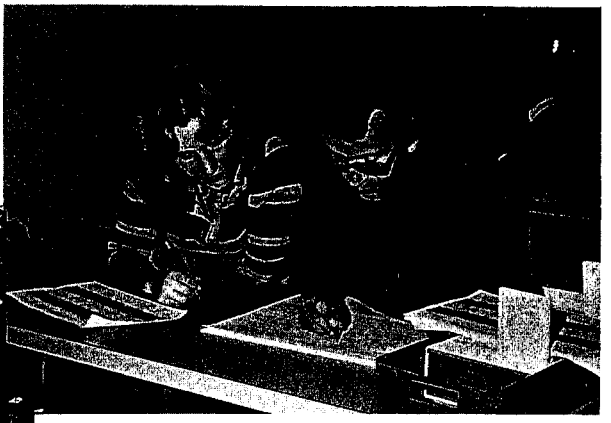
119. An accurate prescription is not possible without accurate inventory information. The best prescription will do the stand no good if improperly applied.

120. Sale layout and marking personnel need to fully understand the intentions of your prescription to apply it properly. Timber sale administrators have to ensure that logging activities can and do meet the requirements of the prescription.

119

120

121

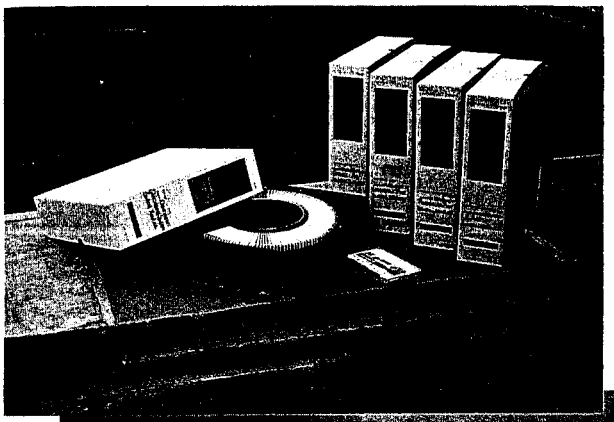


122

121. Finally, accurate long term records need to be kept to insure that future activities within the stand are consistent with your original prescriptions and that such activities are properly scheduled.

122. Proper management is possible only i every member of your management team works together.

123



124

123. This program is one of a series giving the state of the art in silviculture of timber species in the Central Rocky Mountains. To obtain other slide programs in this series, or publications dealing with these subjects, contact the Forest Service Headquarters of the Rocky Mountain Forest and Range Experiment Station in Fort Collins, Colorado.

LITERATURE CITED

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