

Grasses in Young Conifer Plantations— Hindrance and Help

Abstract

Grasses often hinder the establishment of conifers in plantations by preempting resources, chemically excluding natural seedlings (allelopathy), attracting insects and animals, and increasing the fire potential. Grasses generally are not desirable in conifer plantations less than five years old, but after five years, they can aid conifer seedling growth by physically and chemically excluding more competitive vegetation. In plantations over five years old on good sites with deep soils, grasses can be beneficial by excluding deeper rooted shrubs. On poor sites with shallow soils, grasses and shrubs often compete throughout the profile and no benefit accrues to conifer seedlings by converting to grasses.

Introduction

Grasses in young conifer plantations often lead to conflicting points of view. Most foresters advocate little or no grass in conifer plantations. Most range managers favor at least some grasses, provided that they are palatable. Do grasses deter or enhance conifer seedling survival and growth? Should plantations contain grasses that lower seedling growth, but facilitate grazing? Or should plantations contain no grasses (or other competing vegetation) and therefore no grazing, but promote higher seedling growth? These questions reflect the need for information on conifer plantations when grasses are present or likely to be so. Needed even more is the understanding that grasses can both hinder and help. The key is to know when and where.

At an International Symposium on "Foothills for Food and Forests," held at Oregon State University in 1983, speakers from the United States, New Zealand, Australia, and the United Kingdom presented papers on how best to utilize the forage present in developing conifer plantations (Hannaway 1983). In the United States, studies on growing trees and livestock together are underway in several areas including the Pacific Northwest, California, and the Southeast. That opportunities exist for the production of forage while a conifer plantation is developing into a forest not only is a fact, but also is of great interest. Increasing production from the same land is attractive to a world ever in need of more food and fiber.

Ecologically, grasses are markedly successful worldwide. Over 5000 species have been

catalogued—1500 species in the United States alone (Logan 1982). Not only are grasses extensive above ground, but they occupy much area below ground as well. Nearly 85 percent of the total standing crop of live plants in North American grasslands is below ground (Trappe 1981). The combined roots and root hairs of a single 4-month-old cereal rye plant grown in the laboratory had a total root surface area of 237 m² (2554 ft²) and a total length of 623 km (387 mi) (Robbins and Weier 1950, 125-126). These values are many times greater than for conifer seedlings. Although rye grass plants develop much faster than most perennial grass seedlings, the magnitude of root and root hair development below ground demonstrates the strong competitive nature of grasses relative to young conifer seedlings. And some grasses begin root growth long before conifers, especially in cold soils. Capability to begin root growth early and to rapidly expand absorbing surfaces into large soil volumes allows the grasses to capture scarce moisture and nutrient resources. Fueled by these resources, shoot growth also is rapid. Together, grass roots and foliage preempt site resources to the point that conifer seedlings either cannot become established or, once established, cannot grow at the potential of the site.

Most plantations consist of planted or seeded conifers on ground denuded by some form of site preparation. In this disturbed environment, the opportunity for grasses to become established is great, especially if seed already is present or a seed source is nearby.

Grasses As A Hindrance

Grasses hinder seedling establishment in young conifer plantations by preemption of resources, allelopathy, attraction of insects and animals, and increased fire potential.

Preemption of Resources

In northeastern California, where soil moisture was the major limiting factor, Roy (1953) found that survival of planted pines varied with ground cover of shrubs and grasses. After two years, survival ranged from best to worst on bare ground with no stones, slash, open stony ground, shrub cover, and grass cover. Another study in northeastern California showed that 80 percent of ponderosa pine (*Pinus ponderosa* Dougl. ex Laws. var. *ponderosa*) seedlings died when planted in a sown mixture of one-year-old grasses (Baron 1962). Only 30 percent died when no grasses were present.

In a laboratory and field study on root competition between ponderosa pine seedlings and grasses in Arizona, grass roots grew faster than pine roots. Main roots of mountain muhly (*Muhlenbergia montana*) and Arizona fescue (*Festuca arizonica*) elongated 50 percent faster and consequently occupied a given soil volume sooner than pine roots. Root weights of grasses also were greater than pine seedling roots after two years (Larson and Schubert 1969). In a related experiment with the same grass species, most ponderosa pine seedlings, planted three months after the grasses, were suppressed or dead (Rietveld 1975). Furthermore, the two studies constituted "an awesome demonstration of the competitive power of fescue and muhly" (Rietveld 1975).

Scalping, or the removal of grasses and forbs from small areas around conifer seedlings, was evaluated on east-facing slopes in Mendocino County, California. Grasses and forbs were removed in 1.8-m and 0.9-m (6-ft and 3-ft) squares around Douglas-fir (*Pseudotsuga menziesii*) seedlings. The 0.9-m (3-ft) square was "not sufficient clearing of grasses and forbs to provide good survival" (Adams 1975, p. 15-17). A similar study of young ponderosa and Jeffrey pine (*Pinus jeffreyi*) seedlings in the foothills of the central Sierra Nevada showed similar results. Deep scalps 1.1-m by 1.2-m (3.5-ft by 4-ft) wide were

created around seedlings in the spring. In June, survival was 93 percent and height growth excellent. By August, few seedlings were alive. Masses of grass roots from plants bordering the scalps had fully occupied the cleared areas, including the ground directly under the planted pines. Young grass plants also became established in the scalped areas and added to the competition. Together, the grass plants robbed the pines of essential soil moisture. Significantly, the tallest grass plants in the plantation were those bordering the scalps (J. L. Jenkinson, Pacific Southwest Forest and Range Experiment Station, pers. commun.).

Not only are conifer seedlings negatively affected by grasses, but so are conifer saplings and small poles. Growth of pole-sized pines on relatively shallow soils in eastern Oregon was hindered by bitterbrush (*Purshia tridentata*). After removing the bitterbrush, perennial Idaho fescue (*Festuca idahoensis*) invaded and decreased diameter growth of the pines even more (P. H. Cochran, Pacific Northwest Forest and Range Experiment Station, pers. commun.). In northeastern California, where relatively shallow soils predominate, different combinations of shrubs and grasses were created beneath a stand of pine poles. After five years, basal area growth of pines increased 28 percent over the control when grasses were removed and 6 percent when broad-leaved shrubs were eliminated (Gordon 1962). Wright (1978) noted that similarly-sized stands in Arizona were partially thinned by grasses.

In these examples, reductions in conifer survival and growth can be attributed to preemption of scarce resources by the more aggressive grasses.

Allelopathy

Allelopathy is the process whereby a chemical substance released from one plant inhibits the presence or growth of another plant in the same or nearby habitat (Tukey 1969, Rietveld 1975). Allelopathic interaction between grasses and other plant species most often occurs when the other plants are small. Inhibition of germination and radicle or shoot elongation are typical.

Although extracts of many plants are toxic to other plants in the laboratory, few demonstrate toxicity in the field. Toxic metabolites in the

natural environment are neutralized by several factors, including adsorption on soil colloids, microbial activity, or possible inactivity because of xeric conditions (Tukey 1969). Grasses that show toxicity to conifer seedlings in the field are important to foresters and ecologists.

Few species of grasses, relative to the total number in the United States, have been screened for toxicity in the laboratory or field. Sixteen grasses (Table 1) have demonstrated toxicity in bioassays (Rietveld 1975, Heisey and Delwiche 1983). Most also are toxic in the field, or suspected of being so.

Allelopathy in grass and its effect on conifer seedlings is best shown in a study of ponderosa pine in Arizona (Rietveld 1975). A statistically significant reduction in pine seed germination rate, total seed germination, and initial radicle development took place from chemicals predominantly in live foliage, and to a lesser extent in dead residues of Arizona fescue and mountain muhly.

TABLE 1. Grass species known or suspected to be toxic in the field.

| Common Name | Scientific Name |
|--------------------|--------------------------------|
| Foxtail fescue | <i>Festuca megalura</i> |
| Western wheatgrass | <i>Agropyron smithii</i> |
| Big squirreltail | <i>Sitanion jubatum</i> |
| Squirreltail | <i>Sitanion hystrix</i> |
| Cheatgrass | <i>Bromus tectorum</i> |
| Blue grama | <i>Bouteloua gracilis</i> |
| Timothy | <i>Phleum pratense</i> |
| Soft chess | <i>Bromus mollis</i> |
| Ripgut brome | <i>Bromus diandrus</i> |
| Medusahead | <i>Elymus caput-medusae</i> |
| Broomsedge | <i>Andropogon virginicus</i> |
| Threeawn | <i>Aristida oligantha</i> |
| Johnsongrass | <i>Sorghum halepense</i> |
| Bermudagrass | <i>Cynodon dactylon</i> |
| Sudangrass | <i>Sorghum sudanese</i> |
| Rabbitfootgrass | <i>Polypogon monspeliensis</i> |

In the southeastern United States, loblolly pine (*Pinus taeda*) seedlings decreased in abundance and size if growing in fields of broomsedge (*Andropogon virginicus*). To ascertain the cause of this phenomenon, Priester and Pennington (1978) prepared live, dead, and decaying shoot extracts of broomsedge and applied them to four-week-old loblolly pine seedlings. The extracts of

live and decaying broomsedge shoots significantly reduced pine stem, root, and needle lengths. Significant reductions in oven-dry weight for both stem and root portions also were noted.

Toxicity can affect plant community composition. Community makeup often results from toxin production in some species and toxic tolerance in others (Muller and Muller 1956). In Oklahoma, for example, the annual grass threeawn (*Aristida oligantha*) effectively invades the early seral sunflower (*Helianthus annuus*) community because it tolerates the allelopathic environment created by the sunflower. In turn, threeawn dominates for several years by allelopathically suppressing nitrogen-fixing bacteria and blue-green algae, thereby rendering soil nitrogen levels too low to support species in subsequent seral stages (Wilson and Rice 1968). Such a process could affect plant succession and also conifer seedling growth.

Attraction of insects and animals

Site preparation and subsequent vegetation control measures often cause shifts in vegetation and population dynamics of associated organisms. On the west-facing slopes of Mount Shasta, California, thousands of acres of brushfield were cleared to establish conifer plantations. One large compartment was treated with herbicide to create fuel for broadcast burning. After a successful burn, ponderosa pine seedlings were planted. Several years later, shrub seedlings and sprouts were again treated with herbicide. Consequently, competing vegetation shifted from woody shrubs to grasses (*Bromus* spp. and *Stipa* spp.). Wingless grasshoppers (*Bradynotes obesa*) became epidemic. A year later, pocket gophers (*Thomomys* spp.) increased substantially. The shift from shrubs to grass and corresponding increase in grasshoppers and pocket gophers caused the loss of most of the pine seedlings (McDonald and Tappeiner 1985).

Competition from grass is commonplace in pine plantations throughout the southwest and is recognized as being important in reducing ponderosa pine survival and growth (Pearson 1942, Larson and Schubert 1969). Larvae of the southwestern pine tip moth (*Rhyacionia neomexicana*) also can reduce height growth of young ponderosa pines, sometimes by as much as 55 percent over a six-year period. And deformation

from repeated attacks can render seedlings worthless as crop trees (Jennings and Stevens 1982). Most attacks by this moth occur at heights less than 3 m (10 ft) above ground. Consequently, competition from grass and repeated insect attacks can keep pine seedlings below this height for years, each year compounding the loss of seedling growth.

On the Rogue River National Forest in southern Oregon, a native needlegrass (*Stipa californica*) became the principal herbaceous species in a ponderosa pine plantation. In spite of scalping around each seedling to control the grass and baiting to control the pocket gophers, survival after the first year was 25 percent. Grass invaded the scalped areas and the pocket gopher population recovered after the first growing season. After eleven years, less than one percent of the pines remained—over 1000 seedlings had been lost after the first year. Pocket gophers “were the main cause of mortality” (Hermann 1963).

The vole (*Microtus* spp.) also occupies grassy areas and poses a threat of damage to conifer seedlings. The Oregon vole (*Microtus oregoni*) is found in a wide range of habitats in the Pacific Northwest, especially on sites occupied by grasses and forbs common to logged or burned areas (Borrecco *et al.* 1979). Damage, in the form of clipped terminal and lateral shoots and basal debarking, can be serious in young conifer plantations (Lawrence *et al.* 1961, p. 16-17).

Increased Fire Potential

Converting ground cover in a plantation to one or more species of grass often increases fire potential. Moreover, the greater availability of resources resulting from the fire can allow the grass to gain in size and vigor.

On the east slopes of the Cascades, Blue Mountains, and northern Rockies, ponderosa pine is part of the climax community. Where grasses and some shrubs comprise the understory, fire frequency is estimated to be every 6 to 22 years. In the central Rockies, where the forest understory is predominantly grasses, fire occurs every 12 to 25 years. In contrast, fire frequency in the widespread ponderosa pine-bitterbrush community of west-central North America is estimated at 50 years (Wright 1978). These data indicate that predominantly grassy understories

are associated with increased fire frequency, at least in ponderosa pine forests.

Relative to most shrub or tree communities, the spread rate of fire in grasses is often greater. A comparison of fire spread in tall grass and tall chaparral, for example, showed that fire moved 50 percent faster in grass (Albini 1976).

Fire frequency and spread rate are likely to increase when grasses are present in young conifer plantations. And fire may do more good than harm to the grasses. Increases in grass production, numbers, flowers, and seeds are likely within one year after burning, and recovery of perennial grasses is rapid.

Grasses As A Help

Grasses help conifer seedlings in young plantations by exclusion of competitive plant species and allelopathy.

Exclusion of Competitive Plant Species

As noted, grasses compete strongly with conifer seedlings, especially when the seedlings are small and not yet established. After establishment, which generally takes 5 years, grasses may actually aid conifer seedling growth. Although the grasses can negatively affect conifer growth, woody shrubs generally are even more competitive.

A well documented study in central California portrayed the potential that grasses have for controlling woody shrubs (Schultz *et al.* 1955). The shrub stand consisted of wedgeleaf ceanothus (*Ceanothus cuneatus*), chaparral whitethorn (*C. leucodermis*), deerbrush (*C. integerrimus*), and Mariposa manzanita (*Arctostaphylos mariposa*). It was burned in the fall. The following April, new seedlings numbered over 839,500 per hectare (339,500/acre). Ryegrass (*Lolium multiflorum*) and hardinggrass (*Phalaris tuberosa* var. *stenoptera*), each in a separate study, were seeded into the ashes just after the fall rains. A uniform stand of grass was established for each. In August, data showed that grass cover greater than 55 percent for ryegrass and 45 percent for hardinggrass eliminated all shrub seedlings.

Excavations in seeded and unseeded ryegrass plots related competition between grass and shrub seedlings to soil moisture. Where ryegrass had been seeded, shrub seedlings were 5

centimeters (2 inches) tall and roots had penetrated a maximum of 28 centimeters (11 inches). The ryegrass roots had grown downward 137 centimeters (54 inches). The soil moisture deficiency zone, as determined by the wilting point for sunflowers, extended down 122 centimeters (48 inches). In the unseeded plots, shrub seedlings averaged 20 centimeters (8 inches) in height and roots extended to a depth of 109 centimeters (43 inches). The soil moisture deficiency zone extended down only 15 centimeters (6 inches).

Near Mount Shasta, California, dense, mixed-species brushfields are being converted to conifer plantations. Here, a long-term ecological study has shown that a native needlegrass (*Stipa* spp.) invaded areas where the shrubs were removed. Once the grass became established, and this happened 5 to 6 years after the pines were planted, the plots that were initially free of shrubs still were free 18 years later. Shrubs from seeds produced on large plants in windrows nearby or possibly from dormant seeds in the soil, had not successfully invaded these areas (McDonald and Oliver 1984). The mechanism for shrub exclusion could be physical modification of the environment, emission of toxic substances from *Stipa*, or both. But whatever the process, the grass excluded the shrubs and resulted in statistically better height and diameter growth of the pines (30 to 375 percent better than control) (McDonald and Oliver 1984).

Two comparatively new studies in northern California also demonstrate the capability of grass to exclude shrubs. Both studies involved testing a number of manual and chemical treatments that were aimed at reducing shrub populations and enhancing conifer seedling growth. In one study, a species of perennial brome (*Bromus* spp.) had formed a dense stand where deerbrush had been eliminated. In the other, Pacific needlegrass (*Stipa californica*) and rescuegrass (*Bromus catharticus*) had become abundant where greenleaf manzanita (*Arctostaphylos patula*) and Sierra chinkapin (*Castanopsis sempervirens*) were killed. In both studies, the treated plots were about 0.04 hectares (0.1 acre) in size and surrounded by abundant seed producing shrubs. In addition, numerous dormant shrub seeds in the soil were an almost certainty. Yet, annual sampling has shown that once the grass became abundant, no

shrub seedlings have become established. (Data on file at the Pacific Southwest Forest and Range Experiment Station, Redding, California).

The phenomenon of grass excluding shrubs was also noted in a fuelbreak study in central California. Part of the open fuelbreak prepared by a tractor was seeded with perennial grasses and part was left bare (Schimke *et al.* 1970). After five years natural regeneration, including ponderosa pine and whiteleaf manzanita (*Arctostaphylos viscida*), were abundant in the open area. Plants of these species were fewer and smaller when growing with grasses (Table 2).

In the cooler and more moist environment of the Oregon Coast Range, several clearcuttings were broadcast burned and seeded in the fall with perennial grasses and legumes. The grass mixtures were evaluated for effect on western thimbleberry (*Rubus parviflorus*) and red alder (*Alnus rubra*). Bentgrass (*Arrostis tenuis*) had the greatest impact on western thimbleberry, with all plots showing a significant reduction in both cover and frequency during the fifth year. Bentgrass and dwarf intermediate wheatgrass (*Agropyron intermedium*) had the greatest impact on red alder, with significant reduction of cover and frequency in the fifth year (Klingler 1982).

The impact of grass in reducing woody shrubs was also demonstrated in central and southern California. After wildfire, a standard practice is to sow annual ryegrass (*Lolium multiflorum*) as a ground cover for reducing runoff and erosion. In the relatively dry habitat of a large burn, *Lolium* cover reduced jimbush ceanothus (*Ceanothus sorediatus*) seedling density tenfold and slowed shrub height growth (Griffin 1982).

Allelopathy

Just as some species of tree seedlings are hindered by toxic substances from grasses, so do other species of seedlings benefit. Toxic substances from grasses can reduce competitive shrubs, undesirable trees, and even other grasses.

In one instance, toxic chemicals from brome-grass in old fields markedly reduced brome-grass seedlings (Meyers and Anderson 1942). But such documented examples are few, and more research is needed. As noted, only a fraction of grass species in the United States have been tested for emission of toxic chemicals, and an even smaller

TABLE 2. Characteristics of ponderosa pine and whiteleaf manzanita seedlings after 5 years in a grass and grass-free environment in central California.

| Habitat | Density per .0004 hectare* | | Height (centimeters) | | Cover (percent) | | | Perennial grasses |
|---------|-------------------------------|-----------|-------------------------|-----------|--------------------|-----------|---------|----------------------|
| | Pine | Manzanita | Pine | Manzanita | Pine | Manzanita | Annuals | |
| Natural | 15.4 | 19.8 | 24.1 | 25.2 | 7.8 | 15.6 | 32.1 | 0.6 |
| Grasses | 1.9 | 2.2 | 13.2 | 13.5 | 0.2 | 0.3 | 19.2 | 64.0 |

*milacre

proportion of shrub and tree species have been screened for susceptibility to such chemicals. But the potential of grasses to help young conifer plantations also exists. Foresters and resource managers should be aware of this phenomenon and watch for examples of it.

Implications For Management

Survival and growth of young conifer seedlings depends on the availability of resources, especially soil moisture. In California and southwest Oregon, where long, hot, dry summers are typical, soil moisture usually is the limiting factor on nearly all sites, regardless of quality. Competing vegetation further reduces the already limited soil moisture resources. And the better site quality, the faster and more completely the site becomes occupied.

Given that grasses often are strong competitors, the question "How much grass is too much for conifer survival and growth?" often is asked. The answer depends largely on age of the plantation, soil depth, and degree of risk. Only general guidelines are presented, and exceptions are probable.

For newly planted conifer seedlings, one grass plant in a 1.8-m (6-ft) square (about 0.9-m or 3-ft radius) around the seedling early in the season is probably too much (McDonald 1983). The single plant likely will become a large plant with a root system larger than that of the conifer seedling. And after the production of seed, more grass plants soon will be present. Moreover, if one grass plant is present, the odds are that other seeds and plants of grass will be present and they too will mature and produce seed. For these reasons and because of extensive root development and capture of soil resources, grasses should be eliminated in young conifer plantations until the seedlings are established.

For five-year-old conifer plantations on medium-to-good sites, many grass plants per 1.8-m (6-ft) radius probably have less effect than many plants of woody shrubs. Medium and better sites usually are associated with soils over 0.9-m (3-ft) deep, and conifer saplings are less impacted by grasses than by deeper-rooted shrubs.

For five-year-old conifer plantations on poorer sites with soils generally less than 0.9-m deep, the relative rooting depth of shrubs and grasses is not as important. In general, roots of conifers, shrubs, and grasses grow through the soil to a rocky layer. Here, root extension becomes lateral and plants compete for resources on top of the rocky layer. No class of plants has an advantage.

Degree of risk is probably fairly high within a 0.9-m (3-ft) radius of bare ground around each seedling. Less risk is associated with a 1.5-m (5-ft) radius of cleared area. Early indications are that radii of 1.5 m (5 ft) or larger are required to control shrubs (Fiddler and McDonald 1984). The larger radii may be necessary to control grasses as well.

Increasing evidence suggests that early conifer seedling growth is closely related to amount of resources, especially to available soil moisture. Any moisture used by competing vegetation is that much less available for conifer seedling survival and growth. And given a limited amount of moisture, the advantage lies with those plants or species that are present first. Their roots are unimpeded by competitors' roots or chemicals or mycorrhizae, and they are free to exploit an increased soil volume. In turn, shoot growth also benefits. A conifer seedling can capitalize on this process if complete or near-complete control of competing vegetation is accomplished during the first few years. After five years, grass can

increase with little risk of a major reduction in conifer growth because the seedlings are normally well established.

Resource managers need a variety of techniques to counteract deleterious vegetation in conifer plantations. Manual techniques, chemicals, grazing animals, fire, and biological controls (grasses replacing shrubs, for example) figure importantly in controlling or eliminating unwanted vegetation. These techniques, used singly or together, are necessary to accomplish the range of biologic and economic objectives of resource managers today.

Biological controls probably will not be as important as the other techniques, overall, but should always be considered and used where possible. Long-term costs may be lower, especially if additional release treatments are not needed. In sensitive areas, biological control may be the only technique available.

Allelopathy, both as an advantage and a disadvantage, should receive increasing consideration in reforestation. It is significant that successful manual, chemical, or animal release treatments often lead to grass understories in young plantations. The effect on conifer growth by

chemicals emitted from these grasses could become increasingly important in the near future. Certainly, more information on the allelopathic potential of different grass species in different environments is needed.

The effectiveness of grazing animals to control woody shrubs in young conifer plantations currently is being evaluated. In the past, the general feeling was that grazing animals and young conifer seedlings did not mix. In addition to the papers presented at the International Symposium on "Foothills for Food and Forests" noted earlier, a recent study in northern California (Thomas 1984) indicated that damage from sheep to two- to three-year-old ponderosa pine and Douglas-fir seedlings can be minimal, provided that timing and duration of grazing are closely controlled. Furthermore, controlled grazing seems to favor the establishment of grass and to prohibit new shrubs. Close cooperation between range managers and foresters could mean that young conifer plantations with a combined yield will be more productive because the grasses exclude new shrubs and the animals keep the old shrubs from expanding or producing seeds.

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