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Establishment of Conifer Plantations in Northern New Mexico

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Many small communities in the north central mountains of New Mexico suffer chronic unemployment and are economically depressed. Poverty stems primarily from geographic isolation and lack of capital. Through Spanish inheritance land holdings have been divided beyond economic units and many formerly cultivated and irrigated tracts are presently idle or seemingly abandoned.

Through the years, wildling Christmas trees have been cut in the area for supplemental income. Although the retail value of trees cut in the state exceeds one and one-half million dollars, the market is fading because of a growing scarcity of high-quality trees. Because of this and the short growing season (100-120 days), a logical alternative would be to use these lands to grow conifer plantations for Christmas trees and ornamentals.

Plantation establishment will involve many silvicultural practices commonly used in the forests of the Southwest. However, special consideration must be given to cropping history, availability of surface irrigation water, presence of dense stands of alfalfa and perennial grasses, and the lack of shelterwood and mycorrhizae forming fungi. Stand establishment will depend on how well one has tailored silviculture treatment to site and species.

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Mora Research Center, an agriculture experiment station of New Mexico State University, is committed to the development of commercial plantations in the state. Following are suggestions for establishing tree plantations in irrigated mountain valleys and on moderate slopes. These practices could also be applied to windbreaks or seed orchards.

Species Selection

Under irrigated conditions there is a wide selection of species for planting. White fir (Abies concolor [Gord. & Glend.] Lindl.), Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco), and Scots pine (Pinus sylvestris L.) should be considered for Christmas trees. Southwestern white pine (Pinus strobiformis Engelm.) has shown much promise in northeastern test plantations and may also do well on local sites (Heit 1973, Wright et al. 1970) Blue spruce (Picea pungens Engelm.) is in demand and is an excellent choice for ornamental plantations.

Site Selection

Site selection should take into account elevation, aspect and slope, air drainage, and availability of irrigation water. Soil physical properties such as internal drainage, depth and texture are highly important and will ultimately have more influence on plantation survival and growth than any chemical fertilizer that can be administered.

Most potential sites in the Mora Valley are from 7,000 to 8,000 feet. The degree to which frost pockets must be avoided will depend upon species and seed source selection. Only level to moderate slopes should be used and poorly drained sites supporting natural pasture (vega) should be avoided. Soils should be at least three feet deep and relatively free of rocks which interfere with site preparation and machine planting. Although soil reaction tends to be slightly alkaline, this is generally not a serious problem.

Site Preparation

Great importance should be placed on soil preparation prior to planting. Good site preparation will: (1) make planting and irrigation easier, (2) increase survival, and (3) stimulate early growth of trees. Failure to properly level the site and clear brush and other weeds invites greater expense in the long run.

Subsoiling may be required on land where shallow plowing has been practiced many years. Machine planting 8-to 10-inch root systems is quite different from sowing wheat or barley. Also, hardpans produced by tillage can impose a direct limitation on root growth when bulk density is high. Falkner and Malcom (1972) observed in 30- to 40-year-old stands of Scots pine that downward penetration of roots ceased at bulk densities of about 1.5 g/cc. Clay loams easily reach these densities if compacted. Subsoiling should be done when soil is sufficiently dry to fracture the hardpan.

Schubert et al. (1970) pointed out the importance of complete site preparation, rather than partial treatments such as scalping or clearing strips of weeds with herbicides. These practices may be valid elsewhere, but in the Southwest moisture stress subsequent to reinvasion of grasses makes these treatments ineffective in reducing seedling mortality. Heidmann and Thorud (1976) suggested that plowing and disking might also reduce frost heaving since this is closely related to bulk density.

Site preparation should be done a year ahead of planting. Fields should be deeply plowed, disked, and harrowed. Deep plowing speeds root development of newly planted trees, which in turn speeds top growth. For heavy soils site preparation should be done in the fall so that large, hard clods will break into desirable-size granules as a result of freezing and thawing, and wetting and drying. A delay in planting will also afford breakdown of phytotoxic substances produced by grasses (Schubert et al. 1970).

Of course, complete plowing can encourage erosion even on gentle slopes. This can be controlled by terracing, or if necessary, by plowing alternate strips along contours so that planting can be done in the plowed soil.

Planting

Conventional bare-root planting should only be done when trees are dormant and is not recommended beyond mid-May in the Southwest. Unfortunately, the onset of the summer rainy season (July and August, Fig. 1) comes too late for spring-planted seedlings. Substitution of containerized for bare-root stock makes it possible to wait until the rains begin before planting. At the Center, a 1200-tree plantation of five native conifers and Scots pine were machine planted in late July. Seedlings were grown in 9-cu. in. book planters (also called root trainers or Hilsons). After almost a year, survival is between 92-98% for all species. A plantation of white fir planted in mid-August showed less survival (81%), indicating that survival may become proportionately lower as the end of the growing season is reached. Planting too late reduces root growth and increases the risk of frost heaving and spring dessication.

Intensive site preparation makes machine planting easier, possible in some cases. Because one man can auger plant only 200-300 trees per day, hand and auger planting are not suited to commercial plantations.

Two men with a machine planter can plant up to 8,000 trees per day in well-prepared soil, greatly reducing planting costs. Faster planting permits the operation to be completed during brief periods of optimal conditions.

When machine planting, the soil should be friable and flow easily into the planting slit. Fall plowed soils possess this attribute.

Seedling Protection

Because newly planted trees are provided no shelterwood, they are highly susceptible to dessicating winds and excessive insolation. Many techniques have been devised to protect seedlings from these extremes. Furrow planting has increased survival and growth of conifers in several areas subject to summer drought (Wilde and Albert 1942, Stransky 1962) The alternation of cultivated and non-treated strips left in native grass has provided protection, as has shade provided by shingles, logs or stacked twigs. At the Center, the effectiveness of different barriers was tested for Douglas-fir. Some were planted in furrows, while others were planted on scalped areas with or without a single- or 3-shingle barrier. Single shingles were positioned to protect seedlings from mid-day to late afternoon sun. Barriers did the same, but also protected seedlings from westerly winds.

Fourteen months after planting, survival was greatest for seedlings protected by the shingle and lowest for the furrow planted trees, probably a result of silting (Fig. 2). The barrier also caused survival to fall slightly below that of the unprotected seedlings.

Because of the reported (Strothmann 1972) and demonstrated benefits of shade, subsequent plantings included rows of oats or winter rye to protect seedlings (Fig. 3). This technique is used in Russia to grow birch seedlings in nurseries. Only a shallow furrow is used for irrigating to minimize silting.

In addition to wind and sun, seedlings must be protected from grazing for at least 3 to 4 years after planting. Rodents may also pose serious problems and must be considered when developing plans for site preparation and weed control.

Weed Control

The first criterion of plantation success is high initial survival. Because weeds rob seedlings of moisture, high survival requires virtually total weed control. Weeds also cause malformed crowns with poor color, and support unwanted insects and mammals. White fir will be severely affected by competition, while pines will usually show the least damage with Douglas-fir intermediate.

In the Southwest, much attention is usually given to perennial grasses because they grow primarily during the spring dry period of May and June, and are capable of using most of the available soil moisture at the expense of newly planted seedlings (Heidmann 1970). On abandoned croplands seedlings must contend with alfalfa with its high water requirements and ability to strongly compete for moisture in the upper 6 inches of soil.

Weed control is a complex subject and requires much planning and forethought before trees are planted. In fact, a weed control plan from site preparation to tree harvest should precede planting. Among the many factors to consider are registration, persistence, selectivity, method of application, and whether the chemical is used for pre- or post-emergence control. Type of soil and moisture availability are also important since these greatly affect movement and retention of surface-applied herbicides. Soils high in organic matter and clay, for example, tie up herbicides so that more chemical would be required to produce the same effect as in a sandy soil. Time of application is highly important. Applications made after weeds have begun to grow are more costly since much more herbicide may be required to achieve satisfactory results.

Herbicides commonly used in tree plantations can be placed into one of two categories, selective and non-selective. Selective herbicides generally cause little or no damage when sprayed over dormant conifers. Non-selective herbicides must be used before planting or directed so as not to contact trees.

Some representative selective herbicides include triazines (e.g., atrazine and simazine), dichlobenil (Casoron) and mineral spirits. Representative non-selective herbicides include dalapon, phenoxy herbicides (2,4-D and 2,4,5-T), paraquat, and amitrole.

Triazines are highly effective and if one had to choose only one herbicide for use he should probably choose atrazine. Atrazine is ten times more soluble than simazine in water and is therefore much better suited to low rainfall (Flanagan 1969). Atrazine and simazine (1) are registered for use in forestry; (2) provide control principally of annual grasses and some sensitive perennials; (3) show excellent selectivity in conifers (Heidmann 1970, Newton 1974); (4) interfere with photosynthesis of susceptible plants (Ahrens 1974); (5) persist in the soil for more than one growing season; and (6) can be used for both pre- and post-emergence applications provided the latter are made while weeds are immature. However, they are not effective on many deep rooted perennial grasses and forbs, and continued use over several seasons will result in build up of triazine-resistant weeds. Gopher problems commonly asssociated with continued use of triazines may become almost insoluble.

Simazine and atrazine must be incorporated into the soil by rainfall or mechanical mixing. As pre-emergent herbicides they remain near the soil surface and kill newly germinated weeds, and will continue to do so throughout the growing season. Applied after weed emergence they can control young growth. Atrazine is more effective in controlling perennial weeds and grasses at this point because it shows foliage activity not found with simazine (Byrnes 1960). However, this also creates a need for more accurate timing to avoid injury to conifers (Flanagan 1969).

Atrazine has shown promise in controlling bromegrass and alfalfa in the Mora Valley (Fig. 4). In field plots it afforded acceptable control at a lower concentration than simazine.

Casoron (dichlobenil) was least effective but has shown promise in control of weeds not controlled by triazines (Flanagan 1969). It is usually applied on the soil surface during late fall, winter, or early spring when soil temperatures are low (Ahrens 1974). Unfortunately, small conifers are less tolerant to Casoron than to triazines. Douglas-fir is especially susceptible. The chemical kills "from the bottom up" and is therefore hazardous to use on new transplants (Flanagan 1969).

Mineral spirits have been used for decades in forest nurseries for control of newly emerged weeds. However, the need for frequent application makes them somewhat impractical for commercial purposes.

Several systemic non-selective herbicides have successfully killed perennial grasses in the Southwest. Dalapon, (sodium 2, 2-dichloroproprionate) has proven to be the cheapest and is highly effective (Heidmann 1970). It is effective on a wider range of perennial grasses than are the triazines, but can injure conifers when foliar applied. Also, late applications can be taken up by roots of rapidly transpiring conifers and cause damage or even mortality. All registrations have been for pre-planting only (Newton 1974).

Phenoxy herbicides, especially 2,4-D and 2,4,5-T, are commonly used for selective control of broadleaf herbs and brush in tree plantations. However, sprays must be directed away from trees since they can be damaged. Although pines are especially sensitive to 2,4-D in any season, Newton (1974) found that Douglas-fir and white fir can tolerate four pounds and one pound per acre, respectively, when sprayed before bud burst has begun in the Northwest. Because of the limited presistence of phenoxys and dalapon, they have limited usefulness for season-long control with one early treatment.

Amitrole is another systemic herbicide that is effective against most perennial herbaceous plants and certain woody plants. However, it can cause severe whitening of foliage.

Paraquat is a contact herbicide that can kill most green tissue shortly after application. It works rapidly and weeds show damage hours after treatment. Its high mammalian toxicity causes much concern but it is useful as a pre-planting measure.

All of the non-selective herbicides mentioned may be mixed with triazines to achieve an almost immediate pre-plant effect with the former and a residual effect with the latter. Amizine, for example, is a commercial formulation of amitrol and simazine. Paraquat has also been combined with simazine (Ahrens 1974). In the Northwest, Newton (1974) found that various combinations of atrazine, dalapon, and 2,4-D can be sprayed over dormant trees for controlling a wide variety of annual and perennial herbs. Interestingly, atrazine and dalapon mixtures have the spectrum of both ingredients for weed control, and do not have the damaging effect of dalapon alone.

In northern New Mexico, Amizine could be applied on fall plowed land. After spring planting, atrazine could be applied with early spring moisture or tilled.

Irrigation

Irrigation water will be required for acceptable survival and growth rates. Frequency of watering will depend upon the evaporative demand of the atmosphere but on clay loams water will generally be needed every 7-14 days during the first two growing seasons. During the third and fourth years, up to 20 days may pass before water is needed and thereafter every 21-35 days. It is especially important to have water available during bud formation and when succulent new growth appears. New growth may actually droop and die back if water is withheld, resulting in poorly formed trees.

Fertilization

A fertile soil is required to produce dense, dark colored, high quality trees. Trees planted on good farm land will generally require little if any fertilization the first three or five years. In areas where available nutrient content of the soil is poor, the addition of fertilizer will increase the growth rate and quality of trees.

Fertilization of trees at planting time is usually not necessary or desirable because of the danger of root burning. Once trees are established, fertilizer can be applied in bands alongside trees, or scattered evenly under the drip line of the tree. Fertilizer should never be placed in direct contact with the root system.

The rate of application varies considerably, depending on soil deficiency. However, one-third to one-half cup of balanced low analysis fertilizer is generally adequate for newly established trees. Fertilizer should be added in late winter or early spring before the buds have burst.

Lack of nitrogen is generally the most common deficiency, especially on abandoned fields. Common nitrogen fertilizers are urea, ammonium nitrate, and ammonium sulfate. These often produce marked improvements. On a per acre basis the application may vary from 100 to 250 pounds of actual nitrogen. Nitrogen should be applied only where good weed control can be maintained.

Soils low in phosphorus and potassium should be raised to at least 50 ppm of P_2O_5 and 75 ppm of K.

Containerized Seedlings

Two of the main causes of plantation failure in the Southwest are poor physiological condition of seedlings prior to planting, and moisture stress afterward. Poor physiological condition stems from improper lifting and from not keeping seedlings refrigerated properly.

Containerized seedlings minimize the impact of these factors on plantation survival. The container method permits seedlings to begin and maintain rapid root growth in a near-natural condition. Seedlings are thus able to make better use of soil moisture and transplant shock is reduced. Containers also protect seedlings from mishandling. This helps explain the fact that containerized seedlings generally afford an average 20% overall gain in survival over bare-root stock (Hite 1974). Differences are greatest when large volume containers are compared against bareroot stock on adverse sites (Owston 1972, Hite 1974).

Growth rate of outplanted seedlings may also be increased by producing seedlings indoors (Hanover et al. 1976). Under greenhouse conditions, seedlings may be subjected to optimum conditions of water, nutrients, light and even CO_2. Trees are thus subjected to accelerated-growth conditions and can achieve growth indoors in 9 months that required 3 to 4 years outdoors. Much of this response is due to providing continuous light so that the phytochrome system promotes the vegetative or free-growth phase and prevents dormancy. Although trees resume normal cyclic patterns when returned to the natural environment, growth still remains high.

Trees grown under accelerated-growth conditions may also go on to flower earlier (Hanover et al. 1976). Earlier flowering, increased growth rate, and vigor of accelerated seedlings will yield genetic information much sooner than plantations started from bare-root stock.

Rarely mentioned is that it is practically impossible to J-root container seedlings during the planting operation.

Much research is being performed to assure that containerized seedlings are properly inoculated with mycorrhizae-forming fungi before being sent to the field. This is especially important for abandoned fields, lacking forest duff with natural inoculum.

Tree Improvement

Production of accelerated-growth seedlings calls for the best seed available. Provenance studies conducted in the Northeast and elsewhere have consistently shown New Mexico seed sources of Douglas-fir, white fir and blue spruce to be among the best if not the best for Christmas trees or ornamentals. They have excellent color, form, and growth, while suffering little if any frost damage.

Research has begun to find the best sources in New Mexico. White fir seed was collected from 15 sources in 1975 (Fig. 5). In Fig. 6, height growth of container seedlings is shown for these sources from different latitudes, but with similar elevations (8,000-8,200 ft., 2438-2499 m). Growth at time of planting showed a strong clinal relationship; latitude accounting for 96% of the variability between sources. The southern sources grew more than twice as fast as some from the forests near Mora. Several studies have shown that it is sometimes possible to increase growth rate by using seed collected from more southern sources. In Sweden, it was possible to increase growth rate of Scots pine by using seed collected 300 to 400 km south of the planting site without risk of serious winter injury (Eiche 1966). Time will tell if this can be achieved with the more southern sources of white fir.

Hail may accompany some of the more severe summer thunderstorms that pass over the area. Plantations at the Center received moderate damage from a storm last fall and significant damage from a recent severe storm. Hail may therefore pose a more serious threat to plantations than formerly thought.

Following the recent storm, relative hail damage for 30 international sources of Scots pine was recorded. Data are shown for the Turkish sources which should do well in the area (Fig. 7). On a scale of from 1-5, 1 = no visible damage, 2 = less than 25% needle loss, 3 = 25-50% loss, 4 = 50-75% loss, and 5 = 75-100% loss. The study showed that one source, Sarikimis suffered only slight damage while the most damaged sources suffered 25-50% needle loss. Some attention should be given to these differences in predicting overall performance of seed sources.

Summary

Establishment of tree plantations will require intensive site preparation for weed control and machine planting. Weed control, portection from livestock and rodents, and irrigation are essential to high survival and production of high quality trees. Among the many advantages containerized seedlings have over conventional bare-root stock is the possibility of planting in July, when precipitation markedly increases. Containerization combined with superior seed sources should move plantations past the slow-growth phase much sooner than observed in the past.

Literature Cited

Ahrens, J. F. 1974. Weed and brush control from seedbed to harvest. Amer. Christmas Tree Jour. 18:11-18.

Byrnes, W. R. 1960. Chemical weed and brush control. Amer. Christmas Tree Jour. 4:13-16.

Eiche, V. 1966. Cold damage and plant mortality in experimental provenance plantations with Scots pine in northern Sweden. Studia Forestalia Suecica, Skoghogskolan, Stockholm.

Faulkner, M. E., and D. C. Malcolm. 1972. Soil physical factors affecting root morphology and stability of Scots pine on upland heaths. Forestry 45:23-36.

Flanagan, T. R. 1979. Herbicidal weed suppression for improved Christmas tree production. Amer. Christmas Tree Jour. 13:39-48.

Hanover, J. W., E. Young. W. A. Lemmien, and M. Van Slooten. 1976. Accelerated-optimal-growth: A new concept in tree production. Michigan State Univ. Agric. Exp. Sta. Res. Rpt. 317, 16p.

Heidmann, L. J. 1970. Preemergent herbicides for preparing ponderosa pine planting sites in the Southwest. USDA For. Serv. Res. Note RM-164,4p. Rocky Mt. For. and Range Exp. Sta., Fort Collins, Colorado.

Heidmann, L. J., and D. B. Thorud. 1976. Controlling frost heaving of ponderosa pine seedlings in Arizona. USDA For. Serv. Res. Pap. RM-172, 12p. Rocky Mt. For. and Range Exp. Sta., Fort Collins, Colorado.

Heit, C. E. 1976. Seed testing and growing limber and Mexican border pines. Amer. Christmas Tree Jour. 20:3-9.

Hite, W. A. 1974. Container field performance in the Rockies and Plains. In R. W. Tinus et al. (eds.) Proc. North American Containerized Forest Tree Seedling Symposium, Denver, Colorado. P. 306-309.

Newton, M. 1974. Mixing herbicides for optimum weed control in Pacific Northwest conifers. Down to Earth 30:13-17.

Owston, P. W. 1972, Field performance of containerized seedlings in the western United States. Proc. Annual meeting, Western Forestry and Conservation Assoc., Portland, Oregon.

Schubert, G. H., L. J. Heidmann, and M. M. Larson. 1970. Artificial reforestation practices for the Southwest. USDA, Agric. Handb. 370, 25p.

Schubert, G. H., and J. A. Pitcher. 1973. A provisional tree seed-zone and cone-crop rating system for Arizona and New Mexico. USDA For. Serv. Res. Pap. RM-105, 8p. Rocky Mt. For. and Range Exp. Sta., Fort Collins, Colorado.

Stansky, J. J. 1962. Furrows and pine survival during drought. Tree Planters' Notes 53:23-24.

Strothmann, R. O. 1972. Douglas-fir in northern California effects of shade on germination, survival and growth. USDA For. Serv. Res. Pap. PSW-84, 10p. Pac. Southwest For. and Range Exp. Sta., Berkeley, Calif.

Tuan, Yi-Fu., C. E. Everard, and J. G. Widdison. 1969. The climate of New Mexico, 169 p. State Planning Office, Santa Fe.

Wilde, S. A., and A. R. Albert. 1942. Effect of planting methods on survival and growth of plantations. Jour. For. 40:560-562.

Wright, J. W., F. H. Kung, R. A. Read, R. J. Steinhoff, and J. W. Andresen. 1971. Nine-year performance of Pinis flexilis and P. strobiformis progenies in Michigan and Nebraska. Silvae Genetica 20:211-214.