NURSERY AND AFFORESTATION PRACTICES IN INNER MONGOLIA, CHINA

RICHARD W. TINUS

Richard Tinus (deceased) was a Research Plant Physiologist at the Forest Sciences Laboratory, USDA Forest Service, 2500 South Pine Knoll Drive, Flagstaff, Arizona, 86001.

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Key Words

Bareroot nursery, container nursery, overgrazing, cultivation, vegetative propagation, poplar, windbreaks

In mid-October 1999, I visited Inner Mongolia at the request of the Forestry and Agriculture Organization to evaluate nursery practices and afforestation programs designed to protect the soil and provide wood products. Inner Mongolia is a narrow region of northern China immediately south and east of the country of Mongolia. It stretches from east to west about 2,000 km, equivalent to the distance from Minnesota to western Wyoming. The predominant native vegetation type is grassland; existing forests are all man-made. I was headquartered in the town of Tongliao, near the eastern border of Inner Mongolia on the 44th parallel north latitude. This location has a climate similar to central South Dakota. Precipitation is about 400 mm per year, concentrated during the growing season. Winters are cold and dry. Further to the east is the region of Manchuria that has higher precipitation and is largely forested. Many of the trees being tested for use in Inner Mongolia are native to Manchuria. At the far western end of Inner Mongolia is the Gobi Desert, with rainfall less than 100 mm per year. There is great concern regarding the rate of expansion of this desert in recent history.

The vicinity around Tongliao is heavily farmed, as is most of eastern Inner Mongolia, and this has resulted in major soil conservation problems. Loss of soil from wind and water erosion and loss of organic matter and fertility from intensive crop removal is widespread. Erosion is a problem because fields are usually without windbreaks and plowed to the edge of unprotected drainages (Figure 1). Extremely low levels of soil organic matter and fertility are common because of the high demand for plant materials for food, fodder, and fuel. For example, the aboveground portions of corn plants are harvested for human and cattle consumption, while the base of the stalk and roots are removed from the fields for home heating fuel. Cover cropping and fertilizer application to add organic matter and nutrients are not practiced.

Lowlands not suitable for cultivation are used for pasture. Pasture soils commonly have a very high percentage of sand and become shifting dunes with over-grazing (Figure 2). Some sand dunes have been planted with trees to stabilize the soil and reduce surface wind speeds, but with continued grazing and removal of lower tree branches for fuel and household products, these plantations are often rendered ineffective.

Lands historically reserved for trees are the hill tops (Figure 1). Scots pine *(Pines .ylvestris L.)* and Japanese larch *(Larix* sp.) are the predominant species. The wood is harvested for fuel and furniture. Homes are constructed of bricks or mud blocks due to the scarcity of wood. Opportunities for afforestation under these conditions are great. One success story is clonal poplar culture.

POPLAR CULTURE

Nurseries, such as in Tongyu, maintain stool blocks of local genotypes for vegetative reproduction. Poplar shoots are trained to one stem per rootstock, and by autumn, the stems are 4 to 5 m tall and 5 to 7 cm in diameter. These are harvested after leaf fall to produce poles 1.4 m long. After all branches are removed, the cuttings are fall-planted with only two buds above ground in holes drilled by auger (Figure 3). Because the

Figure 1. Corn fields southwest of Tongliao are without windbreaks and abut unprotected drainages. The gully is about 60 m deep at the level of the stream, visible behind the partially illuminated poplar. Scots pine from Manchurian sources, and Japanese larch are planted on the upland rolling hills.

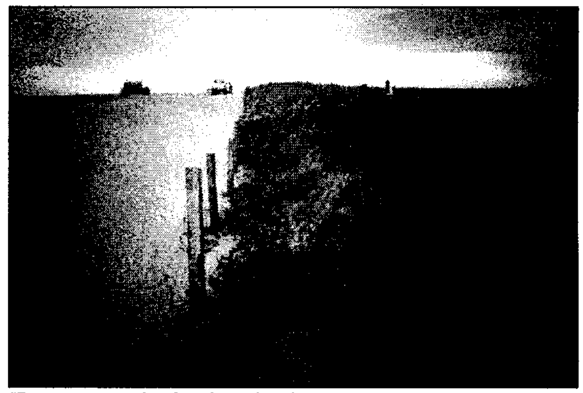

Figure 2. Lowland soils with a high percentage of sand are not suitable for cultivation and can become shifting dunes with overgrazing. Land to the right has been protected from grazing with fencing.

Figure 3. A poplar cutting windbreak being installed in a field of harvested sunflowers. The cuttings are 1.4 m long and 5 to 7 cm in diameter and are planted a few meters apart with only 2 buds above ground. (Closely spaced stalks in the foreground are sunflowers.) The tractor belongs to the poplar planter rather than to the individual farmer.

Figure 4. An eight-year-old windbreak of poplars (recently thinned) and Scots pines. Poplars are 12 m tall and 20 cm in diameter. The forest established on the hilltop in the background is of Scots pine and larch.

soil profile is almost entirely fine sand, this technique works well for establishing the poplar cuttings. Irrigation is not needed.

About 10% of farms have windbreaks. Rows of poplars are often planted adjacent to rows of Scots pine (Figure 4). Poplars after eight growing seasons in the field are 12 m tall and 20 cm in diameter. Commercial thinning is common once poplar windbreak trees reach this size.

One problem with the poplar culture to date is that most all the trees planted represent just two clones. Since this is a genetic risk, a research program is devoted to finding additional clones that will do well. Provenance plantings typically contain about 40 clones, and though only about 10 years old, have quite a number of clones performing well. Genetic diversification should be possible in the near future.

An additional difficulty associated with poplar windbreaks is the practice of pruning up the branches as high as can be reached with a pole saw and a ladder (Figure 5). The farmers do this to harvest the one-year-old whips for fuel or to make baskets and other household items. Since the economy is resource poor, baskets and heat are perceived more valuable than wind reduction and erosion control. To relieve the harvesting pressure on windbreak biomass, block plantings of poplars are being established, as are large plantations of Scots pine.

SCOTS PINE PRODUCTION

A topic of great public interest is the relative performance of the local Scots pine plantations. Most agroforesters in this region of China are not traveled and have nothing to compare with their forests. The leader growth on the Scots pine indicates that they are growing well (Figure 6). The leaders are about 50 cm long without irrigation or fertilization. However, the closely spaced whorls at the base of the trees suggest the establishment period takes two to four years. Improved nursery and planting practices may speed establishment.

The largest Scots pine forest of the region is also the oldest at 40 years (Figure 7). It is currently being logged on an individual-tree basis for sanitation purposes to reduce a serious *Dothistroma pini* needle blight infection slowing tree growth. Though logging was not intended to begin this soon, the forest is producing a valuable commercial product (Figure 8). Because the trees are growing on 500 mm of rainfall, about half that of their native range, the forest cannot be expected to have the longevity or disease and insect resistance of Scots pine forests within the native range. Similar to trees on the Great Plains of North America, longevity is about half that of trees within the native range. This in no way suggests that the practice of establishing Scots pine forests for the future of Inner Mongolia should be abandoned. These forests are providing valuable services where no native species are present.

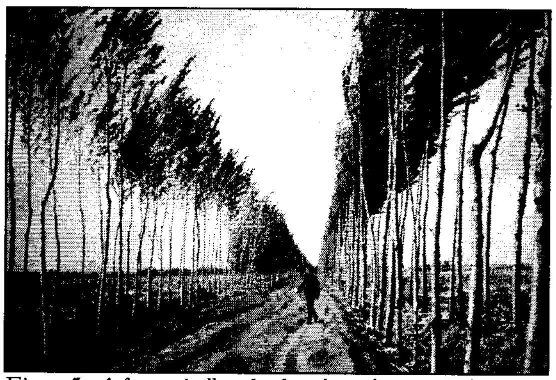

Figure 5. A farm windbreak of poplars along a rural road near Tongyu is pruned because the branches have greater value for fuel and the manufacture of household items than for wind and erosion reduction.

Figure 6. Examination of growth at a 10-year-old Scots pine provenance plantation near Zhanggutai by Professor Jiao Shuren, Senior Officer, State Forestry Administration. The trees are performing well. New leaders are about 50 cm long.

Figure 7. The largest Scots pine forest in Inner Mongolia is being logged after 40 years to remove trees infected with Dothistroma pini *needle blight.*

Figure 8. The 3 x 5 card next to 40-year-old Scots pine logs indicates typical tree diameters range from 15 to 35 cm when harvested from the oldest Scots pine forest in Inner Mongolia. Tree rings indicate good growth rates until the last few years when the trees became infected with Dothistroma pini *needle blight.*

BAREROOT CONIFER NURSERY PRACTICE

The Zhanggutai Nursery is the only such facility in northern China. It is a center for research, production, introduction of new species, and development of nursery techniques. Production is 600,000 bareroot seedlings, primarily 2+0 Scots pine. Soil pH is 6.5, which will be lowered to 5.5 over time by incorporating ground sulfur. Seeds are surface sterilized with potassium permanganate solution before sowing to reduce damping-off. Soil fumigation is yet to be tried. An irrigation system of moveable pipe and impact sprinklers is used. Artificial fertilizer is of limited availability and only applied to research beds. Good quality seedlings are being produced despite lacking some of the equipment commonly used in nursery practice. For example, sowing is accomplished with a new Italian-made precision seeder. However, seed cleaning equipment is unavailable to remove debris and hollow seeds from filled seeds prior to sowing. This results in germination of about 50% and non-uniform bed density (Figure 9).

Undercutting at 10 cm is done prior to root activity in the spring of 'the second year. This encourages production of fine roots close to the surface that will remain with the seedling when it is lifted. The root pruner is a stationary thin knife that does an adequate job, but would perform better if it were to reciprocate. Lateral root pruning is done with cutter wheels in early summer. A reciprocating root wrencher is used in late summer to stress the trees and induce bud set. Lifting is done in the spring by drawing a blade without movement under the seedlings (Figure 10). Scots pine seedlings (2+0) have good root growth in the fall when grown at a bed density of 200 seedlings per square meter (Figure 11). Seedlings are not lifted in the fall due to the absence of seedling storage facilities. However, overwintering in the ground at the nursery is difficult because of cold, dry, windy conditions, combined with unreliable snow cover. Burying the seedlings in sand is currently used to reduce desiccation, but is labor intensive and hard on the seedlings. Hoophouses over the beds, using white plastic with 70% shade, is an option being considered for use in conjunction with nursery windbreaks.

Figure 9. Non-uniform bed density in one-year-old Scots pine at the Zhanggutai Nursery resulted from sowing inadequately cleaned seed with a precision seeding machine.

Figure 10. The blade used to lift seedlings at the Zhanggutai Nursery.

CONTAINER NURSERY PRACTICE

Container production is in its infancy in Inner Mongolia and is severely limited by the greenhouse facilities available. The greenhouse at Naiman is representative of structures currently in use (Figure 12a). The 30 m x 8 m greenhouse faces southeast for maximum light intensity and has a freestanding brick wall to the north to keep out the cold. The bows of the house are of poplar. The covering is blue plastic held down in windy conditions by corn stalk mats rolled up to the peak of the roof when not in use. Since the blue color of the plastic filters out photo-synthetically active radiation, sources of clear plastic are being sought. There is no means of artificial heating, and cooling is accomplished by cutting holes in the plastic. Seeds are hand sown in April into plastic-lined paper pots containing a mix of sand and black humus. Containers are placed on the soil floor of the greenhouse. Irrigation water is available at a hand pump well 75 m from the greenhouse (Figure 12b), and is transported to the plants in 10-L watering cans and applied by hand. Fertilizer is not used. Most seedlings are shipped and planted during the rainy season in June after a brief 20-day hardening period in the greenhouse with the plastic removed. Seedlings at the time of shipping are commonly small (12 cm tall, 2.5 mm stem diameter), actively growing, and suffering from the stresses of widely fluctuating greenhouse temperatures, often in excess of 40 °C. Survival is poor, and establishment can take a few years.

Some suggestions to improve seedling quality include: 1) use of a rigid wall container with multiple grooves and an egress hole at the bottom that is supported for air pruning; 2) use of a lighter media such as a fibrous peat mixed with vermiculite, perlite, or coarse (3 to 4 mm) sand, and slow release fertilizer; 3) use of mechanized irrigation to provide sufficient and uniform watering; 4) sowing earlier to allow more growing time and 40 days to harden; and 5) use of a vent system that is easy to open and close, and a thermohygrometer to monitor conditions.

OUTPLANTING PRACTICE

Establishment of tree plantations requires successful execution of a series of steps from seedling production, to site preparation and planting technique, to post-planting grazing and weed control. There are many young plantations where it is evident that great care was taken at each step. For example, protection is often elaborate (Figures 13a, 13b) with fences and moats to exclude cattle, and scalping in the immediate vicinity of the seedlings to reduce competition, while leaving weeds beyond a

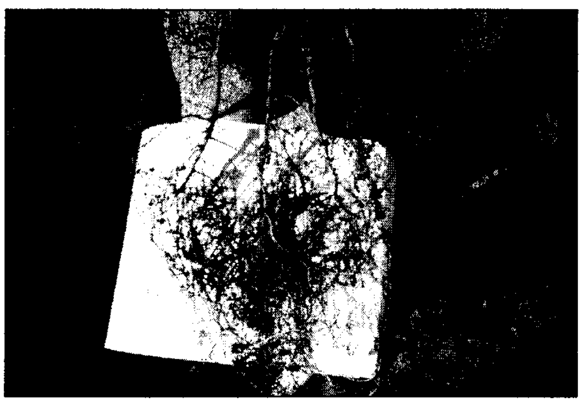

Figure 11. October root systems of 2+0 Scots pine seedlings pruned to 10 cm at the beginning of the second growing season at the Zhanggutai Nursery.

Figure 12b. The only source of water for the greenhouse is this hand pump well. Surrounding fields are of cabbage, a winter cover crop at the nursery.

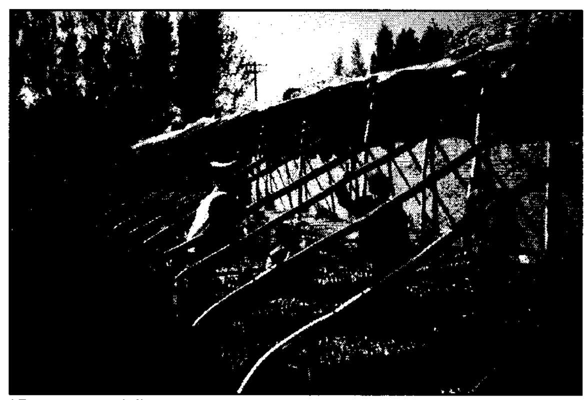

Figure 12a. The Naiman Research Nursery greenhouse. Seedlings have been shipped. The blue plastic skin is rolled up the roof in preparation for winter. Wu Aimin, Chief of the Division of Publicity, State Forestry Administration, crouched at left, films the tour.

Figure 13a. Grazing protection includes fences and moats. Evidence of successful plantation establishment a generation ago is evident on the skyline.

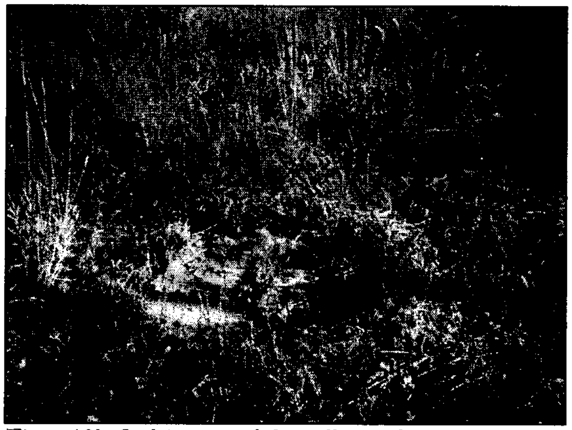

Figure 13b. Scalping around the seedlings reduces competition while outlying weeds offer wind protection and soil stabilization.

Figure 14. A sparse 10-year old Scots pine plantation still experiencing mortality resulting from spiraling of roots during container production.

meter to provide wind protection. From a distance, areas like those in Figure 13 look like fields of weeds, but the surrounding healthy Scots pine forest plantings (background Figure13a) serve as a testimonial to the success of this approach.

When failures occur, a common cause of seedling mortality is improper planting affecting root form. `J'- and `U'-shaped root systems on bareroot seedlings, and balled, spiraled, and bagged root systems of polybag seedlings are found. For example, at a 10-year-old Scots pine plantation (Figure 14), trees were gradually and mysteriously dying while neighboring naturally established woody shrubs were thriving. The trees had been produced as 1.5 m balled stock. The roots developed spiraled and are now strangling the trees. Training new local tree producers and planters is an ongoing challenge here, as it is throughout forested regions.

PROVENANCE PLANTINGS OF ADDITIONAL SPEPIES

Genotypes from the Great Plains of North America are being tested for suitability in Inner Mongolia. Jack pine *(Pinus banksiana* Lamb.) is performing comparably to the Scots pine in test outplantings. Ponderosa *(P. ponderosa* Laws.) and lodgepole *(P. contorta* Dougl.) pine genotypes are not doing well because the seed sources are from 52° north latitude in Canada. South Dakota sources, closer to the 44° north latitude of Inner Mongolia, will soon be planted. Performance should improve. Eastern redcedar *(Juniperus virginiana L.)* seedlings from South Dakota sources were planted a year ago. Many are already established and doing well. For greater drought resistance, Rocky Mountain juniper *(Juniperus scopulorum* Sarg.) will be added to the trials. *J. virginiana is* native from the east coast of North America to the middle of the Great Plains, representing a rainfall belt of 130 cm to 500 cm. *Juniperus scopulorum* grows west from there and is native to a rainfall belt of 60 cm to 350 cm. Careful selection of genotypes and expanding contacts with sister nurseries from similar climatic zones will enable diversification of forest plantings in Inner Mongolia.

NOTE FROM THE AUTHOR

I find visiting nurseries around the world very rewarding. It provides the opportunity to learn from the diversity of solutions to similar biological challenges involved in tree seedling production and establishment. I encourage you to participate in these exchanges.