SHELTERBELTS FOR NURSERIES

Richard W. Tinus
Principal Plant Physiologist
Shelterbelt Laboratory
USDA, Forest Service
Bottineau, North Dakota

Abstract

Most nurseries could benefit from both living and artificial shelterbelts, but the wind barriers must be carefully designed to achieve maximum benefit with minimum unfavorable effect. The Bend Pine Nursery is used as an example.

Introduction

All nurseries are occasionally subjected to damaging winds, and many are on light soils susceptible to wind erosion. Most nurseries could benefit from properly designed shelterbelts. Today, I would like to explain what a windbreak 1/ does, and then use the Bend Nursery as an example of a situation where existing windbreaks are a mixed blessing because of poor design, and show how they can be improved.

What a Windbreak Does

Any windbreak has three primary characteristics: height, density, orientation. The primary effect is reduction of wind velocity on the lee side.

The pattern of wind velocity reduction is independent of barrier height, but the protected area is proportional to the height, so, the effect of a windbreak at any distance from it can be measured in terms of multiples of barrier height, H (fig. 1). For complete protection, the array of barriers should be spaced about 10 H apart. That means a row of trees 40 feet tall will protect an area but to 400 feet from the trees, whereas a 4-foot snow fence will protect only 40 feet.

Density affects both the amount of wind velocity reduction and the distance from the shelterbelt at which it occurs. Solid objects and trees with heavy foliage or numerous small stems block the wind to such an extent that turbulence brings high velocity gusty wind back to the ground at distances as close as 2 H. A better windbreak is only

1/ The terms "windbreak" and "shelterbelt" are used interchangeably.

moderately dense so that laminar flow is maintained and less turbulence develops. Such a windbreak will have wind velocities of about 30% next to the belt, compared to nearly 0 for a solid object, but the zone of protection extends much farther from the belt.

For maximum effectiveness, the shelterbelt must be oriented perpendicular to the wind. If it is at an angle to the wind, it will protect less area, and the protected zone will be in a somewhat different place (fig. 2). Naturally, the wind does not always blow from the same direction, so parallel rows of shelterbelts can be planned to protect only from the most damaging winds. Protection from winds from all directions can only be obtained by using shelterbelts on all four sides of each block.

There are many secondary effects of windbreaks caused by reduction in wind velocity. During the day, the temperature within 2 H of the windbreak may be up to 6°F warmer, and from 5 to 20 H, 2-5° cooler (fig. 3). This does not include any effect of shadows. At night the ground surface temperature will be 1-2° warmer. Relative humidity is 2-4° higher. Evapotranspiration is reduced 60% at 1 H and 30% at 10 H, and results in a large decrease in crop water stress during dry windy weather (fig. 4).

Reduced wind velocity means a reduced load of airborne particles, mainly soil and water. Less irrigation water is lost to evaporation, which means less salt buildup and better water economy. Irrigation patterns are easier to place on the crop behind a windbreak, especially on the upwind side. Windbreaks control snow deposition. When properly designed, they can either spread the snow over the cropland for moisture conservation and prevent winter burn on seedlings, or they can keep an area clear of snow (fig. 5). Windbreaks can stop soil erosion, although when spaced farther than 10 H apart they should be used in conjunction with other agronomic practices. It is not necessary to stop the wind, only reduce it below a threshold velocity, which is about 13 mph for the light textured soil typical of tree nurseries.

So far, everything I have said applies to any wind barrier, but there are some additional effects caused by living as opposed to non-living wind barriers. Continuity and uniform density are important to the performance of a windbreak. It is a simple matter to repair artificial barriers to maintain their effectiveness, but trees cannot be grown with complete uniformity, and non-uniform growth, breakage, and death will create holes that are hard to plug. Nurseries have an advantage, however, because they can water, fertilize, control pests, prune, and otherwise take more intensive care of their windbreaks than the average dryland farmer.

Conifer windbreaks maintain uniform density all year, but deciduous ones lose much of their density in the winter. Low winter density can be good or bad, depending on when the damaging winds come and what is being protected.

Trees and shrubs compete with the crop, and a "sapping effect" is often visible out to 1 1/2 to 2 H, depending on species of tree. Such competition is clearly unacceptable in a nursery, but proper selection of windbreak species and judicious root pruning of the windbreak can minimize it.

Another undesirable feature of tree and shrub windbreaks is that they create habitats for birds, rodents, diseases, and nematodes that attack the nursery crop. But again, proper windbreak design and management can minimize the problem. For instance, removal of litter or cultivation under the windbreaks will eliminate much of the rodent habitat, and windbreaks should not be of species which are hosts for diseases and nematodes that will attack the nursery crop (Peterson 1962).

Current Situation at Bend

Figure 6 illustrates the layout of the Bend Nursery as of November 1977. Most of the beds are grouped into 400- x 400-foot blocks surrounded by roadways. About 1/3 of the beds run north and south, the rest lie east-west. On the west, is a windbreak with a row each of ponderosa pine, lombardy poplar and ponderosa pine. The north-south shelterbelt through the middle of the nursery is lodgepole pine. On the north and east, is ponderosa pine and Siberian elm. The east-west rows are ponderosa pine. In addition, there are block plantings mainly of ponderosa pine on the west side, along the entrance road, and near the headquarters area. The beds are surrounded by a deer fence. The nursery is bounded on the south by an irrigation ditch, and on the east and north by an increasing number of rural residences.

Bend has a sandy pumice soil which is highly subject to wind erosion, and thus soil protection is needed to prevent seedling damage caused by soil drifting in the beds, and to avoid clouds of dirt blowing into the nearby residential areas.

The strongest and most troublesome winds come from the west during October and November. This means that the most useful tree windbreaks should be oriented north and south and be composed of conifers. Deciduous trees would be of less value in late fall. Notice that the two main northsouth windbreaks are 800 feet apart. For best protection, the trees in the west windbreak need to be 80 feet tall, which they are not.

The east-west windbreaks cast shadows to the north, which delays soil thawing by several weeks in May and thus delays sowing. The shadow undoubtedly reduces growth in the affected beds during the summer. The windbreaks harbor rodents and birds which are responsible for heavy seed losses after sowing. The birds roost in the trees and feed in the shadow of the windbreak. The rodents live underground and in the litter layer and forage In the seedbeds.

The windbreaks are mainly ponderosa and lodgepole pine, which are also the principal species grown at the nursery. The windbreaks, therefore, tend to form a reservoir of insects and diseases which will attack the seedlings.

Near some of the shelterbelts, there is a visible "sapping effect" which reduces seedling growth in those beds.

Feasible Improvements

Windbreaks at Bend are essential to the successful operation of the nursery, but the current system is not as effective as it could be. How can it be improved?

First, reorient all nursery blocks to run north and south. This would run them perpendicular to the most troublesome west wind. Then erect snow fence between the water lines at about 40-foot spacing, which is 10 times the height of the snow fence. This is a flexible figure; the exact distance would depend on bed width and irrigation patterns. Note that if the fences were 8 feet high, they would only be needed every 80 feet, so there would be half as many. But this really would not save anything, because the same amount of fencing would be required. A 4-foot fence resting on the ground can be supported by 5 1/2 foot T-bar fence posts. It occupies very little space, and is easily removable when not needed. An 8-foot fence needs heavier more permanent support and lateral braces which would be in the way.

The fence should rest on the ground for maximum soil protection. If water lines can be laid on the ground midway between fences, the snow fence will help keep the irrigation pattern intact when the wind is blowing, particularly on the windward side of each block. Complete protection with. snow fence will reduce evaporation and transpiration stress, and should result in better water economy and bigger seedlings.

Snow fence has the additional advantage that it can be put in service immediately at its full height. It does not take years to grow, nor does it take much lateral space or compete with the seedlings. This is especially important in a nursery that is already pressed to capacity.

With the installation of snow fence, the nursery is not as dependent on its tree windbreaks. Removal of all of the current east-west windbreaks should virtually eliminate the problem with late spring thaw and reduce the shadows and habitat for birds and mice (fig. 7). Rodent habitat can be further reduced by eliminating the litter underneath the remaining shelterbelts by raking or cultivating. In all conifer shelterbelts which have been pruned to remove some of the lower branches, controlled burning would be feasible, but would not be recommended under hardwoods such as cottonwood or Siberian elm. Also, burning may not be popular with the neighbors.

Siberian elm competes strongly with vegetation at considerable distance from the tree, and after removal of the east-west windbreaks, a row of Siberian elm would remain on the west side of the east windbreak. This windbreak offers little protection for the beds to the west, and the Siberian elm at Bend is of little value in late fall when the wind is worst. It therefore should be removed, but the adjacent ponderosa pine should be retained in case beds are ever installed to the east. Any residual sapping effect of the remaining shelterbelts can be controlled by chisel plowing to a depth of 2 feet at about 3-year intervals. Chisel on the side of the road away from the beds, but stay as far from the trees as possible.

The current north-south windbreaks are valuable and should be maintained, but it is not too soon to begin planning for their eventual replacement. There are several lava ridges running more or less north-south which will never be suitable for beds, but could grow tree windbreaks (fig. 7). Planting the ridges takes advantage of their height to increase the effective height of the windbreak and thus increase the area that the windbreak will protect.

What is now the western windbreak could be extended north and south to the property line, and a single row of tall-growing conifers could be started along the central north-south road where there are none now.

Another place to plant new windbreaks is along the property boundaries on the east and north. These plantings would provide visual screening and reduce dirt blowing into the new residential developments outside the nursery.

Except for the row up the middle, these new windbreaks should consist of at least three rows. The west or north row should be a shrub which will be 3 to 6 feet tall. The middle row should be a medium-sized tree in the 20to 40-foot class, and the inner row should be a tall tree that will reach 50 to 80 feet. At Bend, the choice of species must satisfy the following criteria:

1. Trees must maintain their density in the late fall. Therefore, conifers are the most likely candidates.

2. The trees must be adapted to the area. Bend is hot and dry in the summer and cold in the winter. Irrigation can substitute for low rainfall, but the trees must tolerate dry air and cold winters. Bitterbrush or big sage might be good candidates for the outer row and the native juniper for the middle row.

3. The trees must <u>not</u> be trees that are hosts of insects and disease organisms which can attack species produced at the nursery, yellow pine in this case. Bend is far enough from native stands of ponderosa and lodgepole pine to insulate it fairly well from insects such as tip moth or communicable diseases such as western gall rust. Although some nurseries are located in natural stands of the species they grow, Bend should not throw away the protection that distance from natural stands gives it.

What tall species could be used? Look for some of the less common native species nearby. I believe they found sugar pine not very far from there. Look in the older parts of the nearby town to see what trees have been grown successfully in yards and along boulevards. Perhaps with irrigation, Douglas-fir or one of the spruces would be suitable.

For the same reasons, seed orchards should be some distance from the nursery. The need for maintenance and care by nursery personnel should not override the need to keep the nursery free of insects and disease.

The headquarters area could also benefit by a windbreak on the west. Windbreak composition could be the same as for the nursery beds or it could be thicker than three rows, if there is room.

In summary, I would say that most nurseries can benefit from windbreaks, both living and artificial, but the wind barriers must be carefully designed to achieve maximum benefit with minimum unfavorable effects. The Bend Nursery is a good example of how windbreaks can be used effectively.

References Cited and Suggested Reading

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Stoeckler, J. H. 1962. Shelterbelt influence on Great Plains field environment and crops. U.S. Dep. Agric., For. Serv. Prod. Res. Rep. No. 62, 2 p.

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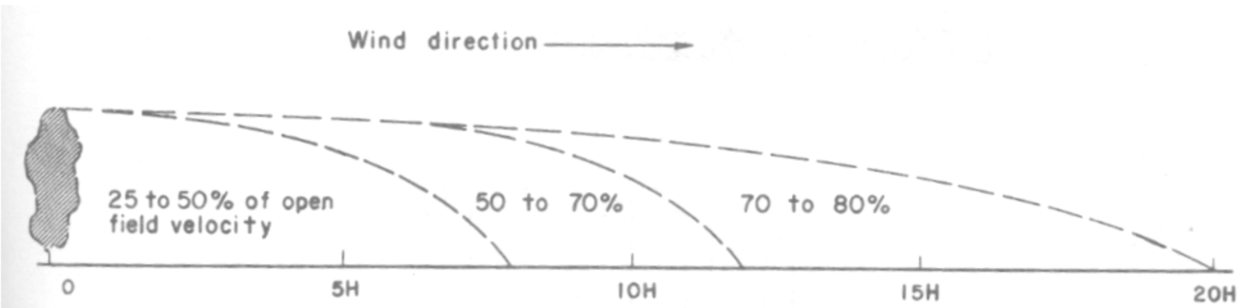
Figure 1.--Wind velocity in percent of open field velocity as a function of



Open field velocity (m.p.h.)	Leeward velocity (m.p.h.) at 5H	10H	15H
20	5 to 10	10 to 14	14 to 16
40	10 to 20	20 to 28	28 to 32

distance measured in multiples of windbreak height (H) (Read 1964).

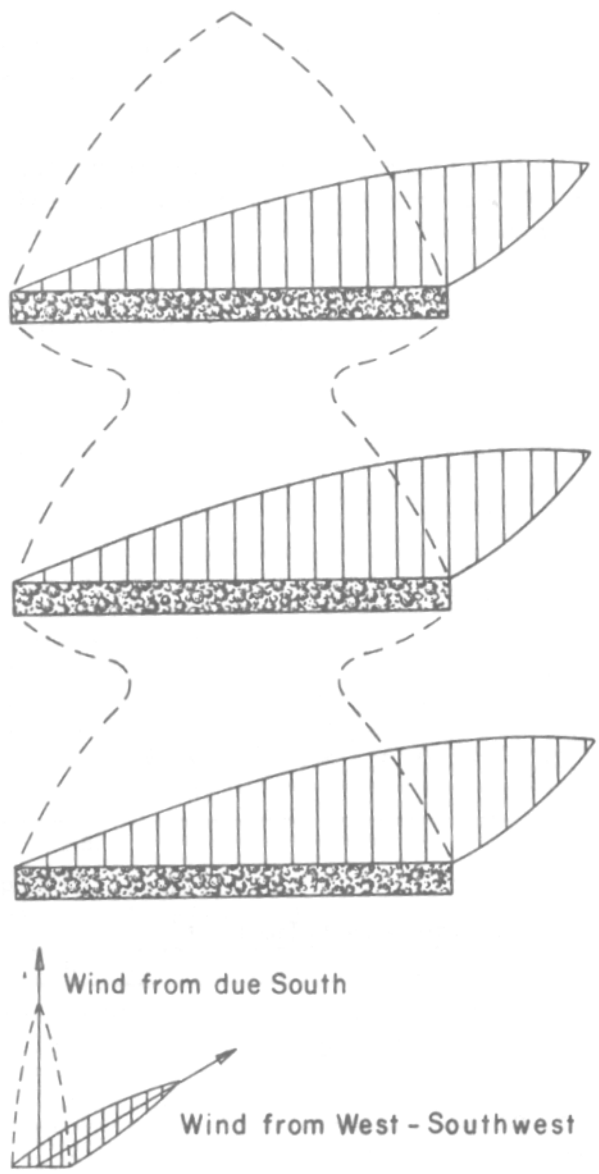


Figure 2.--Comparison of protected areas leeward of parallel barriers when wind direction changes (Read 1964).

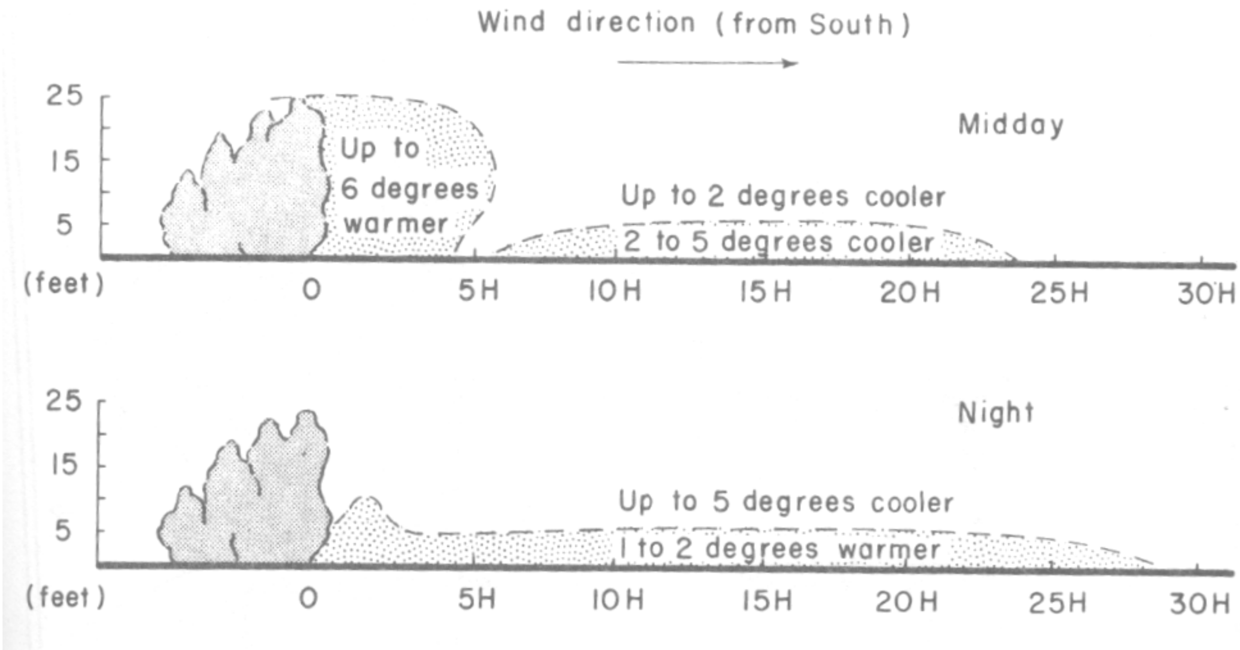


Figure 3.--Air temperature zones leeward of a 25-foot-tall. moderately dense windbreak, compared with open field temperatures. Wind at 14 to 20 mph with open field temperatures ranging from 86° to 110°F in Kansas during July. Vertical scale exaggerated (Read 1964).

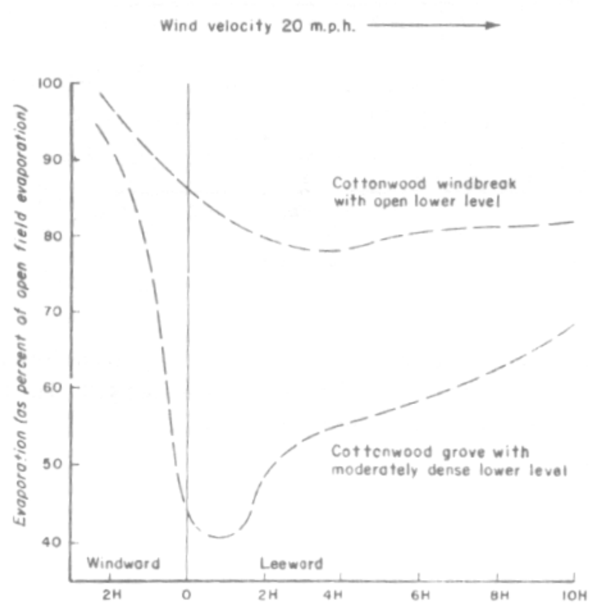


Figure 4.--Percent of open field evaporation windward and leeward of cottonwood windbreaks of different structure (Read 1964).

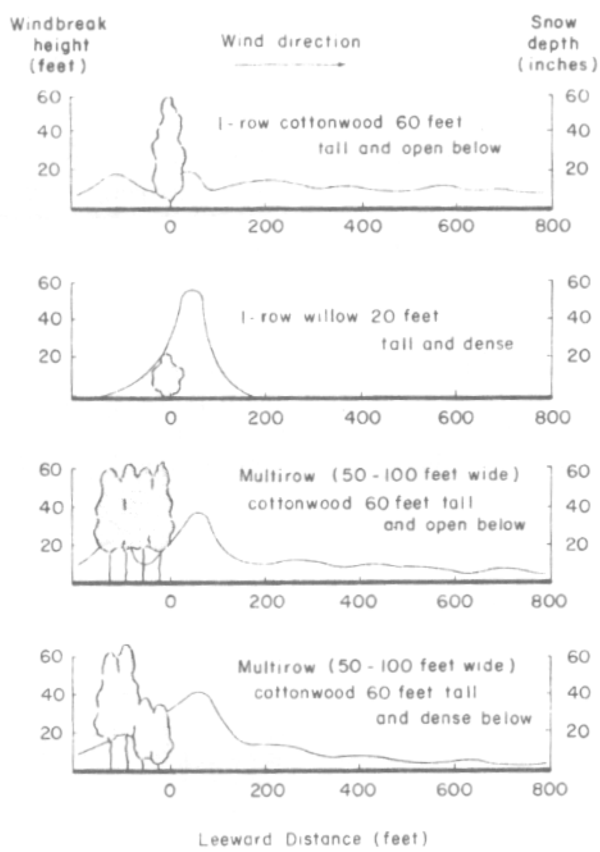


Figure 5.--Profiles of snow depth as influenced by windbreaks of different width and structure. Vertical scales of tree height in feet and snow depth in inches are exaggerated (Read 1964).

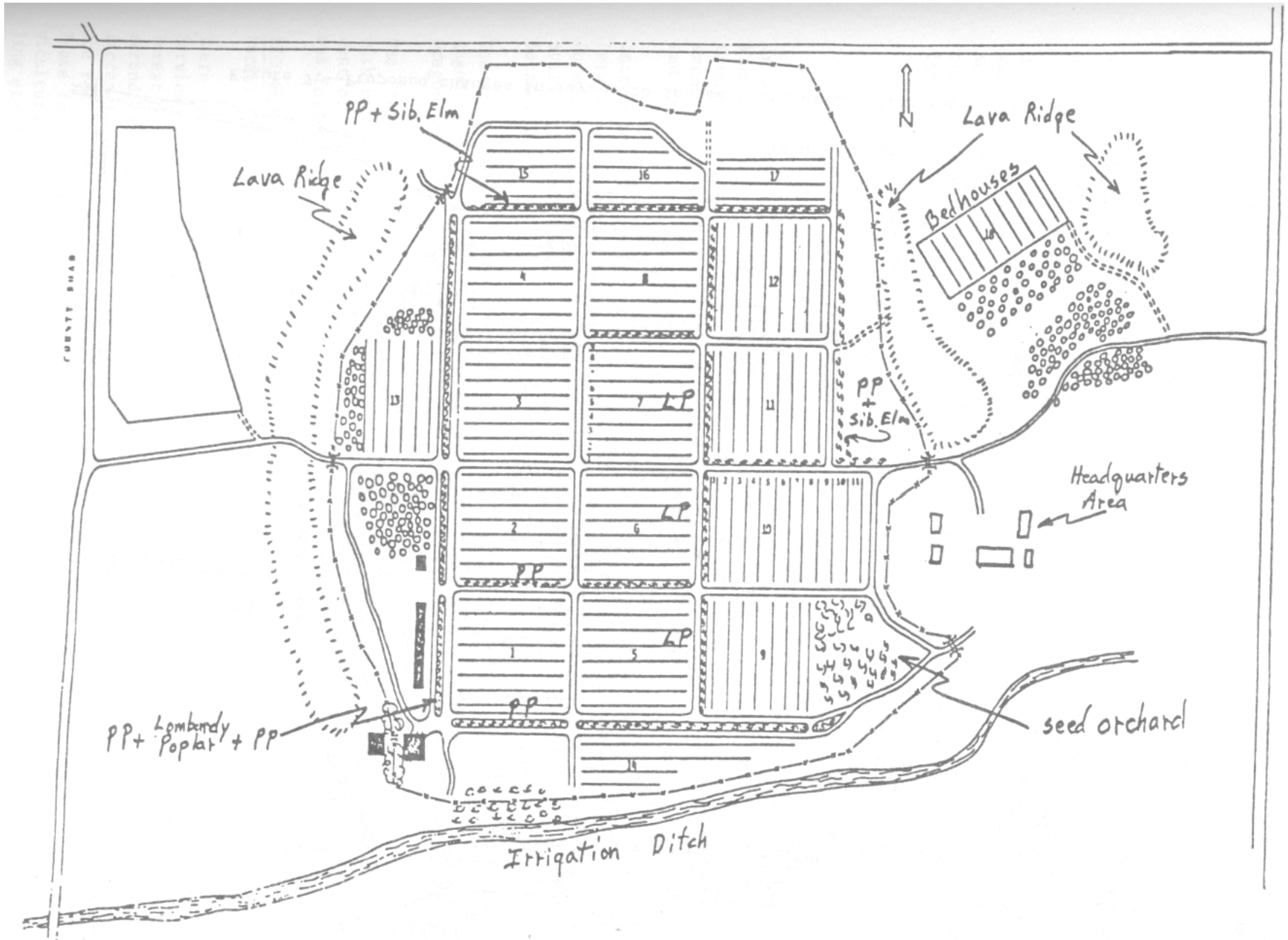


Figure 6.--Layout of beds and windbreaks at Bend Pine Nursery as of November 1977.

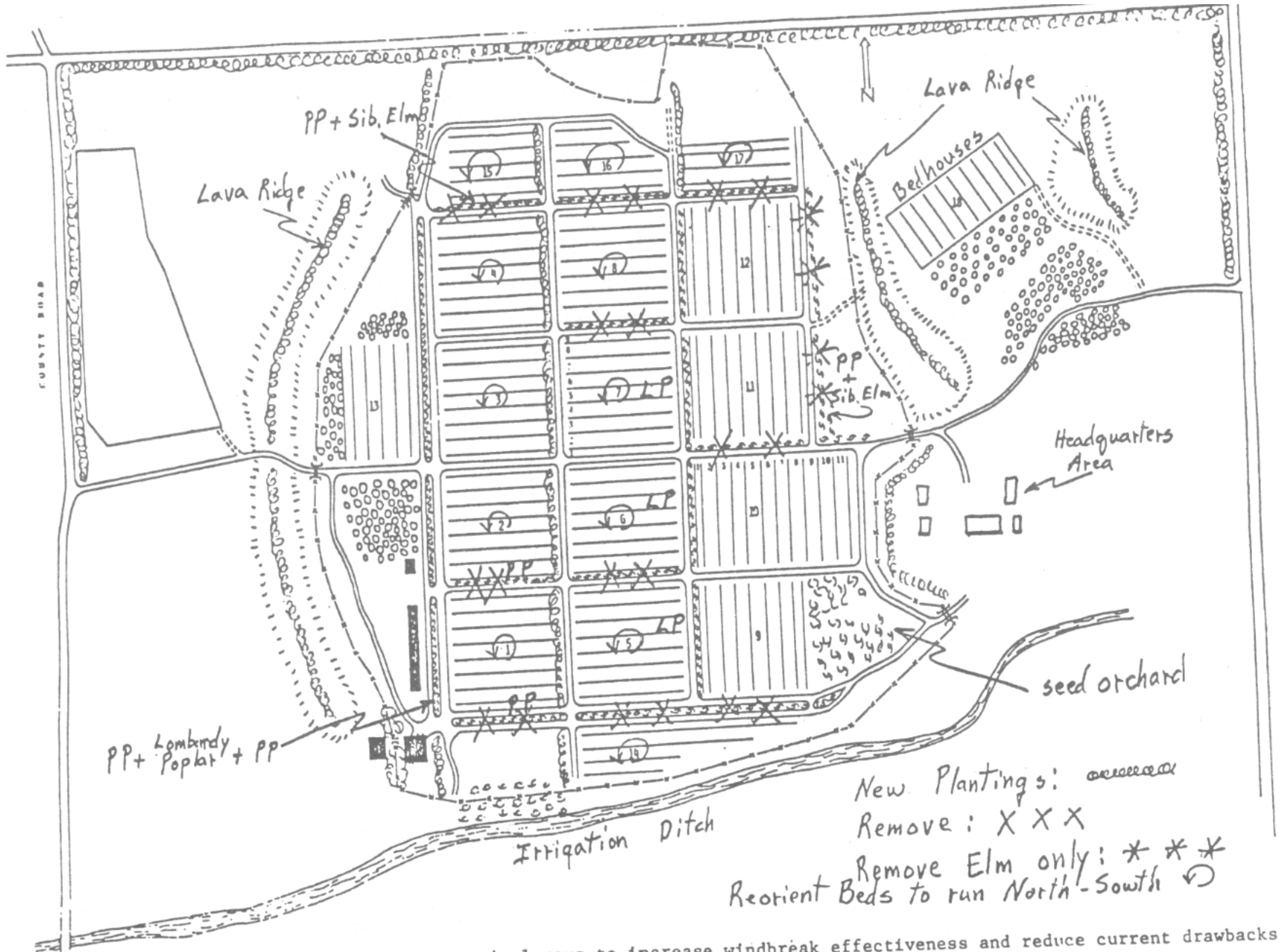


Figure 7.--Proposed changes in layout to increase windbreak effectiveness and reduce current drawbacks.