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FIELD WINDBREAKS

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The value of field windbreaks in preventing soil loss, conserving soil moisture, and thus increasing crop yields is no less important today than it was immediately after the Dust Bowl of 1934. In fact, it may even be more important. Since 1934, particularly since World War II, the demands on farmers to produce more food progressively increased as population increased. To increase production, farmers needed more land, more fertilizer, improved seed varieties, and chemicals for insect and weed control. These needs required more and better equipment. Consequently, there was rapid improvement in technology that brought about vast changes in farming operations.

The horse was replaced by the tractor, and tractors and equipment continued to increase in size. To accommodate this large machinery, the farmer needed longer fields with as few "turn-arounds" as possible. He wanted "clear sailing." Consequently, abandoned farmstead buildings and old fences were torn down, and in some cases farm woodlands were cleared. On some farms field windbreaks were also removed.

During this period of technological advancement, there was a shift from multiple-row to single-row field windbreaks. A few of these windbreaks consisted of trees alternated with a shrub species, but it was soon discovered that shrubs catch too much snow. For the most part, shrubs have been eliminated in more recent plantings in Minnesota and North Dakota where snow is a problem.

Siberian elm was the most popular species planted in Minnesota because of its good initial survival, immediate rapid growth, and its ability to grow in the alkaline prairie soils. Green ash was the second most popular species. It has an excellent survival rate and will grow in alkaline soils, but it does not grow as rapidly as Siberian elm. Poplar species and varieties were also planted, but farmers complained that twigs and branches snapped off and blew into fields where they interfered with seeding and cultivating equipment.

Trees were usually planted on 4-, 5-, or 6-foot spacings (some as close as 2 and 3 feet) regardless of species. In the case of Siberian elm, a combination of close spacing and rapid growth, along with its characteristic dense and wide-spreading branches, resulted in a dense, hedge-like barrier in just a few years. This meant that at close spacings, Siberian elm trapped snow near the trees on the leeward side at an early age. With each succeeding year the trees became more crowded, the windbreak became denser, and the snowdrifts became deeper, narrower, and occurred closer to the windbreak on the leeward side.

Although single-row windbreaks in Minnesota served their primary purpose of slowing the wind enough to prevent fertile topsoil from blowing off the fields, like the earlier multiple-row windbreaks, they were catching too much snow next to the trees on the leeward side. The snowdrifts provided soil moisture for the windbreak trees in the spring, but crops some distance to the leeward were deprived of additional soil moisture. Much of the snow on the leeward side was swept off the cropland by turbulent winds, and through the process of eddying (reverse in wind direction) was blown toward the windbreak. Farmers objected to these snowdrifts for three reasons:

1. Spring farming operations were delayed in the snowdrift area until the soil dried out enough to work.
2. Nutrients were leached out of the soil as the snowdrifts melted, requiring heavier applications of fertilizers in the snowdrift area along the entire length of the windbreak.
3. Spring melt of large snowdrifts often resulted in soil erosion.

Researchers were now faced with the problem of managing established windbreaks with thinning and pruning and designing new windbreaks to prevent soil erosion (figure 1) while allowing snow to settle uniformly over the protected cropland.

Formation of Snowdrifts Behind Windbreaks

Wind approaching the windbreak is forced upward by the tree barrier and by a lower cushion of air that develops on the windward side. The relatively calm air immediately behind (leeward) the windbreak literally sucks the air (and snow)

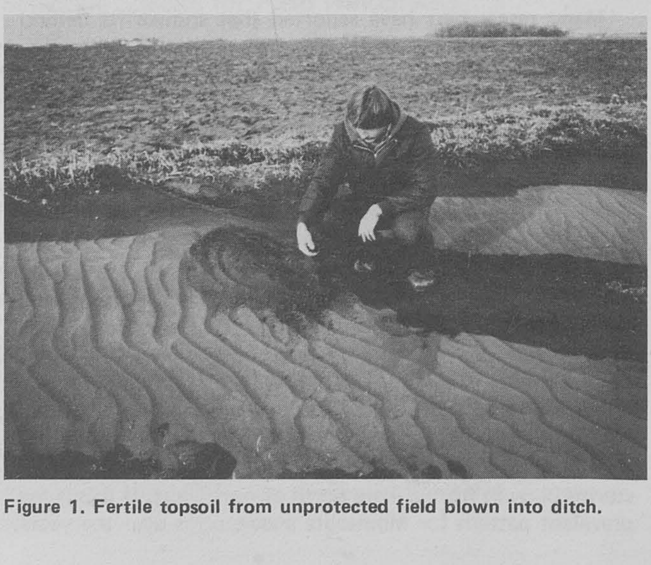

Figure 1. Fertile topsoil from unprotected field blown into ditch.

coming over the trees downward, resulting in wind turbulence and eddying some distance from the barrier. The denser the barrier, the more vigorous the eddying.

Wind action in the region of eddying can be explained as follows: the wind reverses direction behind the windbreak, blowing snow in a rolling or circular fashion toward the windbreak—much like a huge ball rolling toward the windbreak with a reverse spin (rolling toward the windbreak but spinning in a direction away from the windbreak). The more vigorous the blowing, rolling snow, the deeper the snowdrift and the closer the drift behind a dense windbreak. Eddying usually occurs within 10H to 15H (H = average tree height) on the leeward and literally sweeps the snow toward the windbreak, leaving an area of bare land some distance from the windbreak (figure 2).

Figure 2. Bare land in foreground indicates region of eddying where snow was swept toward dense windbreak to form huge snowdrift on leeward side adjacent to the trees.

Factors Influencing Snow Distribution Patterns

The primary factors influencing snow distribution patterns (snowdrift depth, width, and proximity to the windbreak) on the sides of a windbreak are (1) wind velocity, (2) wind direction or windbreak orientation, and (3) windbreak density.

Many researchers have reported that snowdrifts behind (leeward) a windbreak will be *deeper, narrower,* and *closer to the windbreak* as wind velocities increase, the angle of wind direction decreases, and windbreak density increases.

Wind Velocity. As wind passes over the windbreak, wind velocity increases and makes eddying more vigorous. The more vigorous the eddying, the deeper and narrower the snowdrifts and the closer the snowdrifts to the windbreak.

Wind Direction or Windbreak Orientation. Wind direction and windbreak orientation also influence snow distribution patterns. For example, snowdrifts behind east-west windbreaks will become deeper, narrower, and form closer to the trees as wind direction moves from due north and approaches due west.

In northwestern Minnesota where a series of both east-west and north-south oriented windbreaks are located, snowdrifts were deeper, narrower, and closer to the trees on the leeward side of north-south windbreaks. This indicates that snowstorms blow in from a little north of northwest. If this is the prevalent pattern for Minnesota snowstorms over the years, then east-west oriented windbreaks would be recommended in order to get more uniform snow distribution.

Windbreak Density. Dense windbreaks serve their main purpose of reducing soil erosion, but they do not give uniform snow distribution over protected cropland, and they increase chances of crop damage in the zone of eddying. (A windbreak of a deciduous species will be much denser during the growing season when it is in full leaf.) To reduce chances of crop damage and to get uniform snow distribution, it is necessary to design windbreaks that are porous in the lower crown area. This will allow wind and snow to filter through the windbreak (providing weeds and grass are controlled), which will have the effect of greatly reducing wind turbulence and the force of eddying on the leeward side. Windbreak density involves such factors as number of rows, spacing, pruning, and thinning.

1. **Number of rows** — Multiple-row windbreaks, regardless of species, are too dense for uniform snow distribution. They also take too much cropland out of production. Control of soil erosion and snow distribution can be attained with single-row field windbreaks if they are properly designed.

2. **Spacing** — Spacing is determined by branching characteristics. Species having dense crowns and wide-spreading branches, such as Siberian elm, require a wider spacing than a narrow-crowned species, such as green ash. The spacing used in the past—anywhere from 3 to 6 feet—was too close for green ash and much too close for Siberian elm (figure 3). Increasing the spacing of single-row Siberian elm to 10 and 15 feet (figures 4 and 5) did not improve snow distribution patterns. It appears that 10-foot spacing might be recommended for green ash; a spacing of 15 feet may be too open for good protection against soil erosion. The rather open branching characteristics of green ash allows wind and snow to filter through.

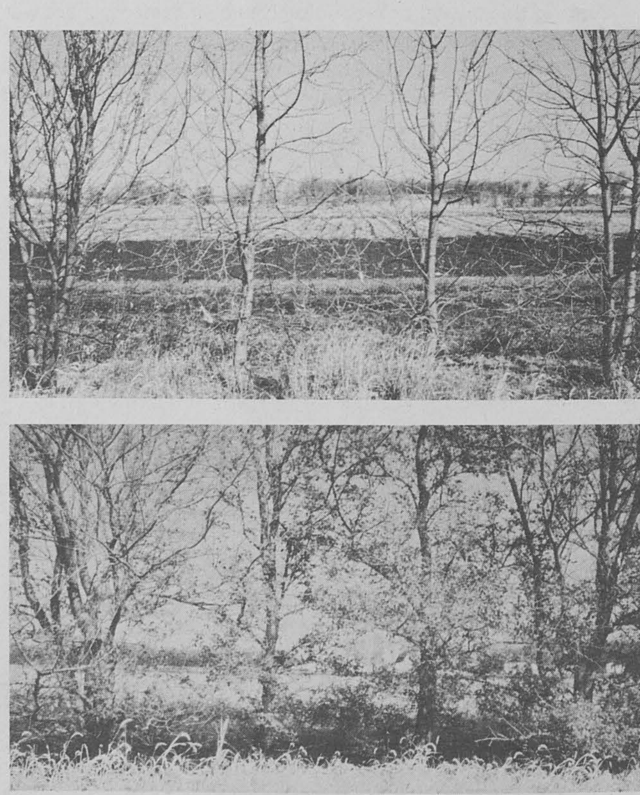

Figure 3. Five-foot spacing of green ash (top) and Siberian elm.

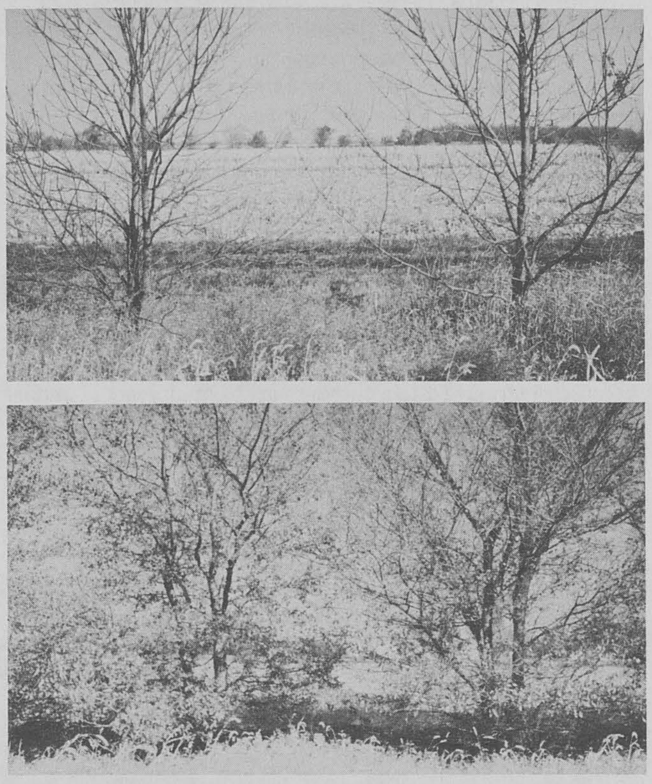

Figure 4. Ten-foot spacing of green ash (top) and Siberian elm.

Figure 5. Fifteen-foot spacing of green ash (top) and Siberian elm.

3. **Pruning** — Snowdrifts along both sides of a windbreak, especially along the leeward side, indicate that the windbreak is too dense. To make existing dense windbreaks, such as those of Siberian elm, more efficient, the lower branches should be pruned. It is not necessary to prune green ash. The main purpose for pruning field windbreaks is to decrease their winter density so more wind and snow will filter through the lower portion of the trees, spreading snow over a wider crop area. Pruning lower branches may encourage grass or weeds to grow in the tree row. This must be controlled for pruning to be effective.

Apparently the height of tree pruning from underneath is critical. Pruning Siberian elm to a height of approximately 3 feet is not enough to get uniform snow distribution. The results of North Dakota studies show that removal of lower branches to a height of 4.5 feet resulted in longer snowdrifts than when trees were pruned to a height of 2.5 feet, and that pruning to a height of 5 feet gave wider and shallower snow distribution than pruning to a height of 4.5 feet. Pruning a Siberian elm windbreak at Crookston to a height of 6 feet proved much too drastic—it provides little barrier to wind and snow.

4. **Thinning** — In a North Dakota study, the removal of every other tree from part of a single-row Siberian elm windbreak where trees were spaced 4 feet apart resulted in 2-foot snowdrifts extending 150 feet to the leeward. Drifts behind the unthinned section were 4 feet deep and extended only 50 feet to the leeward. These results were obtained during a winter of below normal snowfall. Thinning windbreaks where trees are closely spaced is rarely practiced; therefore, trees should be properly spaced when they are planted.

Thinning and pruning Siberian elm may not be a final solution. Thinning may result in prolific stump sprouting, and pruning may result in prolific sprouting at the branch wounds on the trunk. Either form of sprouting, and especially a combination of both, will have the effect of eventually increasing density in the lower portion of the windbreak beyond what it would have been had the windbreak not been thinned or pruned. Planting shrubs between trees would bring similar results.

Selecting Species for Field Windbreaks

Although hardwood (broadleaf) species have been used almost exclusively in single-row field windbreaks in the past, conifers should not be ruled out entirely. Only strains of conifer species having narrow crowns and that are resistant to winter injury should be considered for field windbreaks. There are several advantages that conifer field windbreaks have over hardwood windbreaks:

1. The density of a conifer windbreak does not change between summer and winter because conifers hold their foliage the entire year. This could be an important factor when considering the potential damage to crops as a result of wind turbulence and eddying on the leeward side of the windbreak. If conifers can be managed by proper spacing and pruning from underneath so that wind and snow will filter through to give uniform snow distribution, then wind will also filter through during the summer. This will prevent or greatly reduce wind turbulence and eddying on the leeward and thus prevent or reduce crop damage.

2. Most conifers do not sprout so thinning and pruning would not increase the density in the lower portion of the windbreak.

3. Conifers would provide better winter protection than hardwoods for wildlife.

4. Conifers would add to the aesthetics of the landscape during the winter months—belts of green against a background of dark plowed fields or white snow.

Considerable more research is needed on the use of conifers in field windbreaks.

In selecting a species for field windbreaks, the following characteristics must be considered for each species adapted to the planting site: (1) height growth, (2) branching habits, (3) rooting habits, and (4) resistance to chemicals.

Height Growth. Protection of cropland to the leeward extends greater distances as tree heights increase. This means the taller the trees, the fewer the number of windbreaks required to protect a given expanse of farmland and the less cropland area taken up by trees. Fewer windbreaks also means fewer obstacles for large modern farm machinery.

Branching Habits. Tree species with wide-spreading branches are undesirable for field windbreaks because they shade out more of the adjacent crops and catch more snow than narrow-crowned species. Siberian elm, the most widely used field windbreak species, has wide-spreading branches, while green ash, the second most popular windbreak species, has more vertical branching habits and therefore a narrower crown. Siberian elm also has many more twigs and branches that increase the density of the windbreak and catch too much snow. Unfortunately, most tree species do not develop a narrow crown and, therefore, would not function as ideal windbreak species.

Some of the poplar species and varieties have quite narrow crowns, making them ideal for use in field windbreaks. However, since poplar species are intolerant (unable to grow in shade), the lower branches eventually die when they become too shaded from the upper branches. These lower branches shed naturally soon after they die. When the lower trunks become clear (void of branches) to heights of roughly 6 feet or more, the windbreak becomes too open in the lower portion to slow wind and drifting snow. Another disadvantage of the poplar species is that their branches and twigs are brittle. High winds may snap off branches and twigs and blow them onto adjacent cropland. This can be exasperating to the farmer. For example, when cultivating a row crop, a branch or twig caught in front of a cultivator shoe will root out young crop plants.

Some tree species produce strains with different branching characteristics. For example, some strains of ponderosa pine develop right-angle, wide-spreading branches, while other strains develop angular or slightly vertical branching that produces a narrow crown. (Ponderosa pine, incidentally, is one of the few tall conifer species adapted to many soils of the prairie states and is often used in farmstead shelterbelts.) Also, some strains of ponderosa pine are quite resistant to winter injury.

Siberian larch is a conifer that sheds its needles in the fall. It is a hardy species, has a fairly narrow crown, will grow in alkaline soils, appears to be resistant to chemicals used in crop spraying, and has good growth characteristics for a windbreak species. Researchers in Minnesota, the Dakotas, and Canada believe Siberian larch has great potential for both field windbreak and farmstead shelterbelt use.

Rooting Habits. Ideally, a field windbreak species should have a deep but not wide-spreading root system that does not deprive adjacent crops of soil water and nutrients. Depending on the species, root systems may extend into the cropland a distance of 0.5 to 3 times the height of the trees. Since most of the root system is concentrated under the periphery of the crown, the narrower the crown, the more confined the root system.

Resistance to Chemicals. Since crops are usually sprayed annually for weed control, field windbreak species must be resistant to chemical damage. As mentioned earlier, Siberian larch is quite resistant to chemical spray. Green ash is considerably more resistant than Siberian elm. In fact, the old Siberian elm windbreaks are rapidly dying out (figure 6) because of stress due to a cumulative effect of years of annual crop spraying and lack of moisture due to close spacing.

Figure 6. Siberian elm windbreak dying out due to stress as a result of cumulative effect of annual crop spraying for weed control and close spacing where there are too many trees for available moisture.

Summary. In selecting a tree species for field windbreaks, preference should be given to species with:

1. Maximum height growth.
2. Narrow crowns so that only a narrow strip of adjacent crops will be affected by shading.
3. Porous (fairly open) crowns to allow wind and snow to filter through. (Proper pruning from underneath may compensate for species with dense crowns.)
4. Nonbrittle twigs and branches to reduce the incidence of broken twigs and branches blowing into the field and interfering with farming equipment.
5. Nonspreading root system (usually associated with narrow crowns) to compete as little as possible with crops for soil water and nutrients.
6. A minimum tendency to sprout if windbreak is to be thinned or trees are to be pruned.
7. A high resistance to damage by chemicals used for controlling weeds in field crops.

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