WINDBREAKS AND SHELTERBELTS

JOSEPH H. STOECKELER, ROSS A. WILLIAMS

In an effort to determine the value of adequate windbreaks on American farms, 508 farmers in South Dakota and Nebraska were asked for their opinions. They placed the annual savings in their fuel bill alone at $15.85.

In another measure of the value, the Lake States Forest Experiment Station conducted an experiment at Holdrege, Nebr. Exact fuel requirements were recorded in identical test houses. One was protected from winds; the other was exposed to the full sweep of the wind. From the experimental data it was possible to calculate the savings to be expected under various prevailing conditions, if a constant house temperature of 70° F. were maintained. The amount of fuel used was reduced by 22.9 percent.

Also the average of the savings for houses protected on the north in Holdrege and three other localities in the Great Plains—Huron, S. Dak., Dodge City, Kans., and Fargo, N. Dak.—was 20.2 percent. Assuming a 10-ton annual consumption of coal, this represents a saving of 2 tons of coal a year. Under good protection, on three sides of a house, the fuel saving may run as high as 30 percent.

Dairymen, livestock feeders, and breeders have rather positive ideas of how the protection afforded by trees reduces their feed bills and increases their calf crops. Eighty-six livestock feeders in Nebraska and South Dakota placed this average annual saving at more than $800; 62 livestock breeders reported that their savings amounted to more than $500 annually; 53 dairymen placed their savings at $600.

Further study of the subject was made at the Montana Agricultural Experiment Station at Havre. Two herds of cattle were wintered on the same rations—one in the protection of trees and shrubs, the other in an open lot with some protection from a shed. The tree-protected animals gained 34.9 more pounds each during a mild winter, and lost 10.6 pounds less during a severe winter, than the unprotected herd.

Another experiment conducted by V. I. Clark, superintendent of the experiment station at Ardmor, S. Dak., involved the weighing of two herds of cattle in different pastures—one protected by the natural tree and shrub growth along a stream, the other without protection. They were reweighed after a 3-day blizzard. The animals that had some protection each lost an average of 30 pounds less than those in the exposed pasture.

Farm families depend upon gardens for much of their subsistence, and most of them are aware of the influence of a windbreak in increasing the quality and quantity of vegetables and fruit from gardens and orchards. In the opinions of farmers interviewed, the increase was $67.15 on 323 farms in Nebraska and $84.43 on 260 farms in South Dakota. A few farmers believed the windbreaks did not increase the production of their gardens.

W. P. Baird, horticulturist in charge of fruit and vegetable investigations at the Northern Great Plains Field Station at Mandan, N. Dak., says that “a windbreak is on duty protecting the fruit gardens at all seasons of the year, and it is almost useless to consider growing fruit on the Plains without such protection.”

So far we have discussed windbreaks, which are the shorter and more blocky plantings about farmsteads. Much like them, but more extensive, are the shelterbelts, a term used to denote comparatively narrow strip plantings—sometimes single rows of trees—that are designed to protect fields.

Experience with systematic plantings of shelterbelts to protect fields goes
back to 1789, when a group of German Mennonites, who emigrated to the Russian Steppes, began the shelterbelts that since have been extended to thousands of miles. The term "shelterbelt" was used as early as 1833, so it is apparent that some thought for controlling wind erosion by use of trees was in existence over a century ago. Since the days of the shelterbelt project, initiated in the Great Plains some 14 years ago, the term has become part of the everyday language of farmers on the Plains.

Few tree planters were among the earliest settlers of the United States. They came when the westward migration started to the prairies of Illinois and the Great Plains; those pioneers realized that it was going to take more than a sod house to give them the protection to which they had been accustomed in the wooded East. It was not surprising, therefore, that a plantation of trees often shared with the garden the first patch of sod that was broken. Wildings collected along nearby streams comprised their planting stock. We have records of some of these plantings in Nebraska Territory as early as 1854; many are still alive, monuments to the courage of the pioneers and evidence of the desirability of using hardy, native planting stock. Later immigrants from Europe often brought tree seeds with them from their old homes. The passage of the Homestead Law in 1862 brought more settlers to the Great Plains and the need for more tree planting. Kansas was the first, in 1863, to provide a tree-bounty law in efforts to encourage more planting. This was followed in 1869 by Nebraska and the Dakota Territory which passed tax-exemption laws that favored tree planting. J. Sterling Morton, third Secretary of Agriculture, founded Arbor Day and saw its first official celebration in his home State of Nebraska in 1872. It was primarily through his encouragement that the Timber Culture Act was passed by Congress in 1873. Although it helped to stimulate tree planting, probably fewer than one-third of the trees established during the time the act was in force can be attributed directly to it.

It has been the history of tree planting throughout the world that the establishment of windbreaks and shelterbelts has not progressed fast enough to keep pace with the needs without some assistance by the Government. The thousands of miles of shelterbelts that now protect millions of acres of farm lands in Russia; the mile after mile of tree strips in Jutland, without which farming would be impossible; similar planting in Hungary; the 18,510 miles of tree belts planted in the Great Plains shelterbelt from North Dakota to Texas; and the 211 million trees planted to shelterbelts and windbreaks in the Prairie Provinces of Canada—all owe their success to sound Government policies put into effect through well-administered and Government-assisted projects.

There was a period in the United States after the repeal of the Timber Culture Act in 1891 when little public encouragement was given to tree planters. A renewal of interest was shown in 1904 with the passage of the Kincaid Act and later, in 1916, by the inclusion of the demonstrational tree planting in the program of the Northern Great Plains Field Station near Mandan, N. Dak.

The available records through January 1, 1948, indicate that some 123,191 miles of windbreaks and shelterbelts have been planted since the middle of the past century. Of 96,596 miles planted through private initiative, 39,400 are accounted for by single row Osage-orange hedges planted between 1865 and 1939 by farmers of Kansas, encouraged by a State bounty.

The shelterbelt project, sometimes referred to as the Prairie States Forestry Project, was established in 1934, a time of serious drought, dust storms, and depression. Its purpose was to plant badly needed shelterbelts and at the same time provide work for people in the drought-stricken Great Plains.

In the Great Plains between 1935 and 1942, 18,510 miles of field shelter-
belts, not counting those on farmsteads, were planted by the Forest Service. The Soil Conservation Service of the Department of Agriculture (to which the work was transferred in 1942) planted 8,363 miles between 1934 and 1949 in its program on soil conservation districts. The Wisconsin State Conservation Department furnished stock and, with the Extension Service, was responsible for establishing 5,942 miles of shelterbelts. In California, the fruit-tree growers planted 2,000 miles of belts to protect citrus orchards and vineyards. In Indiana, truck gardeners have planted 100 miles on muck land. Many more miles of shelterbelts for which no published records are available probably have been planted in other States.

The farm plantings before 1935 did not include the large numbers that could also be classified as shelterbelts, but landowners who were fortunate enough to have them in the droughty 1930’s had proof of their benefits. Pioneer planters of shelterbelts and windbreaks in the Great Plains had little knowledge of how to make trees live and only a meager knowledge of the growth habits of the trees they had to use. It is surprising, in view of those handicaps, that even moderate success was attained.

Progressive farmers and orchardists plant shelterbelts for two primary purposes—to control soil blowing and to protect crops. Some southern Great Plains cotton planters find it necessary to replant two and three times on the unprotected fields. Sugar-beet farmers on sandy, irrigated fields in the West frequently have a crop cut off by drifting sand as it emerges from the ground. The small-grain and corn farmers have had similar experiences. From the time that crops are well established until they are ready for harvest, they are constantly subjected to damage or to destruction by soil drifting, wind, firing by hot winds, loss of soil moisture, or damage from frost and sleet. Orchards are subjected to the same damages, but the greatest benefits are realized from protecting the trees during the pollination stage and preventing wind damage to the ripening fruit.

Besides, properly located and arranged shelterbelts can do much to beautify the landscape and act as snow fences in winter, thus helping to keep open highways and rural roads.

Thomas T. Wilson, of the Manitoba Department of Public Works, said that planted snow traps can be considerably cheaper than the usual slat-wire snow fence. His data, based on 201.6 miles of caragana hedge, indicates a prorated cost per mile for a year of about $100, assuming an average effective life of 25 years for the planting. Prorated costs of slat-wire snow fences were about $225 per mile for a year, assuming an average life of 20 years for this type of fence. Hence, the cost of the planted hedges is less than half that of slat-wire snow fence. The comparison, of course, does not consider the possible rental cost of the land the caragana hedge may occupy, but in places where a 200-foot right-of-way is owned, this question is resolved.

The effects on field crops are less distinct. A survey among Nebraska farmers showed that 29 farmers rated high the value of field shelterbelts, although 18 had been unable to observe benefits. The average estimated gain in production amounted to $43 a year. In South Dakota, 27 farmers said the crop gain was $60 a year per farm.

A mistake made by some observers is to note only that corn or small grains growing at the edge of a field protected by the belt is usually inferior to that growing a few rods out in the field, where, in fact, the greatest benefit nearly always occurs. A fair comparison can be made only between both of these zones and the distant part of the field that has no protection. But a large number of systematic measurements throughout entire fields has shown that sound comparison could easily lead to differences of opinion,
because the ground near the belt may be substantially better or poorer than that far out in the field. A farmer with a shelterbelt 40 years old may not remember how the different parts of the field varied in productivity before there was a shelterbelt there.

This variability of production within fields has made so difficult the determination of average shelterbelt gains in the fields measured from 1935 to 1941 by the Lake States Forest Experiment Station that the entire mass of data is being restudied. Predictions as to what will be shown by analyses not previously tried may be erroneous.

In general, however, it appears that a field protected by a single-row shelterbelt, equivalent to the Osage-orange hedge so common in Nebraska and Kansas, will show a net gain in yield equivalent to the crop on an area as long as the belt and as wide as its height, after allowance for shading and sapping. Any belt of greater width will be profitable for protective purposes alone, then, provided its width between the outside stems does not exceed its height.

While it seems apparent that wider belts add somewhat to the benefits, it is probable that the narrow belt yields the greatest return on the land occupied, if the value of the timber products is low. Benefits arise from several different causes, and in consequence are unlikely to be the same in all directions from north-south and east-west belts. Areas west of belts possibly benefit less than those in other directions; in northern parts of the Plains, where the snowfall is heavier, greater benefits apparently are produced than in the central or southern areas.

Winter grains and other early crops may benefit more from the snow held on the field, near the belt, than from other causes, while corn possibly benefits most by protection from hot, drying winds. The final results may be somewhat different from these predictions, and in any case they apply only in the area from the Dakotas to Kansas, and not to the drier portions of those States or to better-watered regions. Except for 1936, when only a few measurements were made, the period does not include any years of serious drought.

**Other crops** besides wheat and corn show good response to shelterbelt protection. An investigation of eight cottonfields in western Oklahoma and northern Texas showed an increase of 17.4 percent above normal between 0 and 5H, and 7.9 percent increase between 5H and 10H (with H representing a horizontal distance of one tree height from the edge of the belt). The normal yield of cotton grown beyond the zone of tree protection was 288.6 pounds of lint to the acre.

In California, one- and two-row eucalyptus windbreaks are said to be effective in protecting citrus fruits from bruising and dropping for a total distance of 5 to 7 times the average height of the trees. The trees easily attain heights of 60 to 80 feet within 10 to 20 years after planting.

H. E. Wahlberg, of Orange County, Calif., reports returns from 20 citrus groves grown under windbreak protection as averaging $445.48 an acre. On 20 unprotected citrus groves, the return was only $271.34 an acre. According to those figures, a grower could use 1 acre of trees on a 10-acre plot for windbreak purposes alone, then, provided its width between the outside stems does not exceed its height.

Dr. Arvil L. Stark, secretary of the Utah Horticultural Society, is authority for the statement that fruit will not set on the windward side of trees when windy conditions prevail, because bees will not work in the wind. Shelterbelts, by reducing winds, thus can create
Wind velocity at instrument stations 16 inches above the ground in 15-mile-per-hour wind blowing at right angles to three types of windbreaks: (1) A 16-foot high board fence of 33 percent density; (2) a dense belt of green ash, 290 feet wide; (3) a thin, rather open cottonwood belt, 165 feet wide. The velocities are given in percentages of wind velocities in an open field nearby.

more favorable conditions in orchards for pollination by bees.

Another benefit of windbreaks was cited by F. L. Overly, superintendent of the Tree Fruit Branch Experiment Station near Wenatchee, Wash. He pointed out that spraying for insect control results in more even and complete coverage in protected areas because of lower wind velocities. Moreover, protected orchard trees do not develop as much lean or become as lopsided as those in exposed areas.

Anyone who has stood in the protection of a belt of trees on a windy day has observed that the wind was considerably reduced near the trees. How much is this reduction in wind velocity, and how far does it extend? The zone of influence is most easily shown graphically. The chart shows what this effect is for a 15-mile-an-hour wind for several different types of barriers. In this study, distances were expressed in terms of windbreak heights, in order to provide a convenient comparison of zones of influence for the tree belts of different heights; for instance, the term $3H$ refers to a horizontal distance equal to three times the height of a tree belt.

It is seen that the wind velocity near a dense wide belt of ash may be reduced to as low as 30 percent of that in the open; for a thin cottonwood belt, it is about 66 percent of normal velocity; for a board barrier, it is about 58 percent. All three windbreaks show some effect out to about 30 times their height, but the effect beyond $20H$ is rather minor.

The results are substantiated by studies made in other parts of the United States.

Pioneer tree planters, especially in Nebraska, planted east-west shelterbelts for protection of fields against south winds. It has often been reported that such protection may reduce the drying power of winds, and may at times prevent the firing of crops when the temperature of southwesterly winds is excessive.
Observation by Alba Briggs in July 1939, in York County and adjoining areas in Nebraska, showed a markedly beneficial effect in reducing the firing of corn—the drying up of foliage in hot, windy weather. Benefits were greatest on the north side of belts and to some extent on the east side. Observations on 8 fields showed no damage out to 11 to 40 tree heights, with an average of 23 times the height of the trees. Tree heights ranged from 18 to 50 feet and averaged about 35 feet. On the south side of Osage-orange hedges of 18- to 20-foot height, accentuated damage to the corn was observed out to 5 tree heights. On the west side, the adverse effect extended from 30 to 40 feet due to firing and sapping. These observations were not carried through to assess values in terms of actual final crop yields, but they show a similarity to many of the yield measurements.

An 8-year-old shelterbelt near Norfolk, Nebr., played an important part in helping its owner, Ernest Fuhrman, to win the 1947 corn-yield contest for his county. His 10-acre test plot made 106 bushels of corn an acre. Mr. Fuhrman said, “I had 90 acres of corn north of the shelterbelt, including the 10-acre test plot, and it was quite evident that the protection the trees gave the field made a lot of difference last year. The best corn was near the shelterbelt and the yield tapered off as the distance from the trees was increased.”

In irrigated areas, shelterbelts can be of considerable value in reducing water loss from evaporation. From Scotts Bluff County, Nebr., it is reported that in growing alfalfa an irrigated field protected by shelterbelts required one less irrigation a season than unprotected fields on nearby farms.

Tree belts trap snow and hold it on agricultural land, especially in the northern and central Great Plains. Hence, some measure of moisture conservation is attained, because in unprotected areas much of the snow is blown into gulches, low spots, and road ditches, where it is of no direct benefit to the crop. Good agronomic practices, such as leaving tall stubble over winter, standing strips of cornstalks, or unmowed sweetclover, can also retain much of the snow on the land. A combination of shelterbelt planting and strip cropping is undoubtedly the best.

In a number of soil-moisture samplings made in the spring of 1936, there was about 4 percent more available moisture (or 2.5 inches of water) in the top 4 feet of soil between the tree belts and a point four times the average tree height to leeward. This additional moisture, largely accumulated from snowdrifts trapped by the belts, may at times be the difference between a fair crop and a complete crop failure.

In developing a shelterbelt, the present-day tree planter can progress with a great deal of assurance, especially if he will seek the assistance of his local State or Federal forester, county agent, or district conservationist.

Although many details involved in the successful establishment of a windbreak or shelterbelt must be worked out to meet local needs, a number of fundamental principles contribute to success, irrespective of the locality or conditions under which windbreaks or shelterbelts may be planted.

Careful preparation of the site, good planting with hardy stock, and thorough cultivation are three factors that go hand in hand. When all three are well done, the results are sometimes spectacular, but one cannot slight one of them and hope to make up for it by intensive application of the others.

Good site preparation means thorough tillage and, if the soil is weedy or dry, summer fallowing for a season. Some sites call for subsoiling, others terracing, contour planting, or, in the drier regions, diking and building of water-diversion structures.

It is extremely important that the planting stock be grown from seed produced in the general locality in which the trees are to be planted. This is one of the principal contributing factors to the unusual success of the shel-
terbelt planted in the Great Plains during one of the Nation's most severe droughts.

Although hand planting is still common and will probably continue to be used for small and rough areas, most windbreaks and shelterbelts will be planted with machines in the future. One type of mechanical tree planter may be constructed by the farmer or his local blacksmith for as little as $175. Others, capable of planting as many as 1,000 trees an hour, are available through purchase from manufacturers, or loan by the soil conservation districts or other agencies.

If hand planting is done, we recommend a long-handled, straight-shanked shovel, such as is common on farms in irrigated areas. The planting job is best if done on well-prepared, reasonably moist ground. On sandy loam or heavy soils, a subsoiler run down the row before planting will loosen the soil and speed up planting. Trees are carried in a metal or wood carrying tray or in a large bucket, and kept covered with wet burlap and some shingle tow or moss.

In using the shovel, the loose, dry soil is scraped off, and the shovel blade is sunk vertically to full depth with the concave side toward the planter; the handle is pushed forward to break out the soil and the shovel pulled toward the planter with the handle inclined slightly toward the planter; the backwall, away from the planter, is made vertical by a second cut and the shovel again drawn back and held to keep the soil from rolling into the hole; a tree is inserted with roots dangling downward, the hole is then half filled and tamped with the heel, then completely filled and tamped again. One man can plant from 50 to 120 trees an hour by this method, depending on the condition of the soil.

In moist soil, planting can also be done in deep, freshly opened furrows. In this method, the tree is held against the vertical side of the furrow without curling the roots and enough soil is scraped with the foot against the roots to hold the tree in place. Then another furrow is plowed against the trees and the soil packed in with the foot or by running the tractor tires over the second furrow-slice and very close to the trees. A crew of one with a tractor, assisted by two helpers, can plant about 350 to 500 trees an hour.

Planting by machine saves labor and time. The planting machines consist of a tractor-drawn trenching device which is mounted on a unicarrier or chassis and which opens a narrow V-shaped trench about 12 inches deep, 4 inches wide on top, and about 1½ inches wide at the bottom. Two men usually ride the machine and place the trees in the open trench, which is then mechanically closed and firmed by packing wheels—all in the same operation. A production of 1,000 to 1,200 trees an hour is generally attained by such machines.

There is a wide range of climate, elevation, and soils in various parts of the United States where windbreaks and shelterbelts are desirable. These factors govern the choice of trees and shrubs selected for planting. Some of the better species mentioned here are used in areas where this type of tree planting is desirable.

The most promising species for the Great Plains include the Chinese elm, green ash, hackberry, honeylocust, cottonwood, white and golden willow, the American elm, boxelder, chokecherry, Tatarian honeysuckle, caragana, eastern and Rocky Mountain redcedar, and ponderosa pine. The adaptability of these and other species in the various Prairie and Plains States is set forth in tables in the last section of this book.

For northwestern United States, including Idaho and the dry-farming areas of eastern Washington and Oregon, the species that have given best results in farm windbreaks and shelterbelts are green ash, black locust, honeylocust, the Chinese elm, caragana, the boxelder, ponderosa pine, Austrian pine, and Colorado blue spruce. On the sites with better moisture conditions, as in low spots or irrigated areas, the
golden willow, silver poplar, and the native cottonwoods do well.

In the Corn Belt region of north-central United States, the trees that have proved adaptable are green ash, American elm, black locust, honeylocust, hardy catalpa, black walnut, the Russian-olive, redbud, honeysuckle, Norway spruce, white spruce, Black Hills spruce, red pine, and white pine. In areas with considerable moisture, the golden willow, green willow, and native cottonwoods are recommended.

In southwestern United States, the citrus-growing sections of Arizona, New Mexico, and California, eucalyptus (sometimes known as bluegum) has been used most satisfactorily to protect citrus groves. In California, Monterey cypress has been used to some extent, while in Arizona and New Mexico, the Arizona cypress is planted occasionally with success.

In the New England States, New York, and Pennsylvania, the planting is usually confined to the farmstead windbreaks, and conifers are favored, including Norway and white spruce, white pine, and red pine.

In the southeastern part of the United States from Georgia westward to eastern Texas, there is occasionally an area of sandy soil that requires protection from wind erosion. Under such conditions the native pine species, especially loblolly pine, makes a satisfactory quick-growing shelterbelt.

Good composition in a shelterbelt, like good structural engineering in a bridge or barn, improves its appearance and increases its effectiveness.

For an all-purpose principal shelterbelt in the drier parts of the United States, one of the most important requirements for good composition is a tight row of shrubs on the windward side.

Shrubs should be combined with conifers, low, medium, and tall trees to produce a compact barrier. Five rows represent the minimum that should be used when maximum protection is needed; seven rows are better.

The protection afforded by the principal shelterbelt may be carried entirely across the farm with one-, two-, and three-row supplemental belts at intervals of 10 rods to 20 rods or more, depending upon the protection that is needed.

In the citrus-growing sections of California and the Southwest, one- or two-row plantings of eucalyptus or cedar give good results. In areas of better rainfall or where experience has shown that narrow belts will survive (for example, on muck soils of Indiana) single-row plantings of willow are satisfactory.

On the sandy soils of central Wisconsin, three-row belts, preferably of red and jack pine, are recommended.

**Thorough Cultivation** is necessary during the first 3 to 5 years of the life of the plantation. No amount of careful site preparation and good planting will compensate for neglect. In most cases, the regular farm equipment can be used in caring for the belts. If the equipment is too wide, some modification can be made by the farmer or his local blacksmith. Usually a spacing of 12 feet between rows will require a cultivation period of 5 years or more, depending on how fast the trees grow. A closer spacing will considerably shorten this period. As soon as the
crowns of the trees come together enough to shade out grass and weeds, cultivation can be discontinued, except in dry areas where rainfall is so scant that continued cultivation is necessary.

Two great enemies of trees are fire and livestock. When fire occurs, it is usually sudden and its destruction is complete; it brings to naught the years of care. The damage caused by livestock is as sure as fire in destroying eventually the windbreak or shelterbelt. Browsing of shrubs and the lower branches of trees and young reproduction opens up the stand to the drying effect of the winds, allows the snow to blow through, and generally reduces the effectiveness of the planting. Constant trampling by stock so compacts the soil that it puddles and seals the surface, and a smaller portion of the precipitation reaches the tree roots; moreover, the trampling may injure the roots or result in breakage or other damage to the stem of the tree.

Tree plantings, if adequately protected, do not demand frequent attention, but the comparatively simple measures that are needed do require timely application.

Pruning of shelterbelts should ordinarily be confined to the removal of dead or diseased trees or broken limbs. Some thinning may be desirable in thickly planted stands or other special circumstances.

After a planting has reached maturity and small openings begin to appear in the crowns, underplanting is important and will fill in the gaps. Usually only very tolerant trees, such as redcedar, will succeed among the older trees.

Joseph H. Stoeckeler is in charge of the Northern Lakes Forest Research Center at Rhinelander, Wis., a branch of the Lake States Forest Experiment Station. He has been engaged in research in the Forest Service since 1931. From 1935 to 1942, when the Prairie States Forestry Project was pushing extensive shelterbelt planting in the Great Plains, he participated in the investigations that provided the technical standards for that project.

Ross A. Williams has been chief of the Division of Forestry for the Northern Great Plains Region of the Soil Conservation Service at Lincoln, Nebr., since 1935. Previously he served with the Forest Service and taught at the Ranger School of the New York State College of Forestry and at Montana State University.

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**HEELING IN**

1. Dig V-shaped trench in moist shady place
2. Open bundles and spread out evenly
3. Cover roots with loose moist soil and water well
4. Complete filling in soil and firm with feet

**CARRYING PLANTING STOCK**

Keep roots covered with water, removing one plant at a time as planting progresses