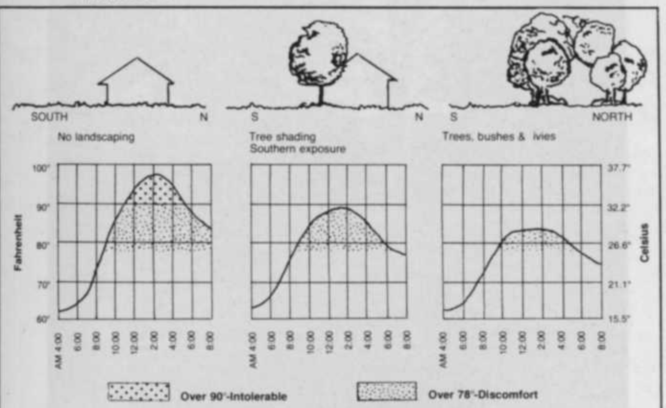
near it, but the overall calming effect extends farther beyond it. The suction immediately behind this penetrable windbreak is less than that produced by a solid barrier, and the acceleration of wind back to its original speed is more gradual.

A windbreak of trees acts as such a penetrable barrier. These windbreaks are most effective when placed perpendicular to the prevailing wind.

Wind Control by Plants

As we have seen, heat loss from a building's surface is proportional to the square of the wind velocity (that is, the speed of wind multiplied by itself). Wind increases heat loss by convection and by adding to the volume of cool air blown into a building, which subsequently may need to be heated. Therefore, a carefully situated windbreak of trees and shrubs can be a powerful energy saver in climates with periods of cool weather.



Landscaping effects on summer temperatures of a house in a temperate climate

Because the quality of wind protection depends on the penetrability, height, and width of the plants used, recommendations for certain species as windbreaks are difficult to make. The more penetrable the windbreak, the more modest wind reflection to leeward, but the farther behind the windbreak this modest protection extends. Dense, coniferous evergreens that branch to the ground provide the most effective year-round plants for wind control, and deciduous trees and shrubs in full leaf are effective in summer.

In general, wind speed is reduced for a distance of two to five times the height of the barrier upwind of an obstruction, and up to fifteen times the height downwind. The maximum shelter from wind is obtained from three to five times the height of the barrier (downwind). Wind velocity is cut up to 80 percent directly downwind of a dense screen planting such as spruce (*Picea* species) trees. For example, a windbreak of two-foot Austrian pine (*Pinus nigra Laricio*) cuts a 12-mile-per-hour wind velocity to 3 miles per hour. A loose barrier of Lombardy poplar trees (*Populus nigra* cv. 'Italica') in full foliage reduces leeward wind velocity by only 40 percent. In general, a leafless deciduous tree has only 60 percent of the wind-blocking ability of its full, "leafed" potential. Irregular windbreaks that have some foliage density throughout their height are most effective at breaking up the airstream over it. Therefore, a mixture of species and sizes of plants makes a better wind control.

The lower wind velocities on both sides of windbreaks encourage precipitation to fall out of the air. This means that small snowdrifts and large snowdrifts may be formed downwind of a windbreak. The rules that explain how plant barriers influence air movements also explain how such barriers affect snowdrifts. The downwind drifts near a solid barrier are deep and do not extent a great distance from the barrier. In contrast, the downwind drifts near a penetrable windbreak are shallow, extending to a greater distance from the barrier. Solid barriers produce drifts on both sides, and more open plantings keep the drift to the downwind side. The greater the velocity of the wind, the closer the drift to the barrier itself. A well-designed windbreak will slow the velocity of the wind and cause snow to be deposited before it reaches a path or driveway. In snowy climates, windbreaks should not be put immediately upwind of driveways or walkways, but rather a considerable distance upwind.

Plants that provide protection from wind to leeward may also produce a pocket of cold beneath them. Plant designs that group trees for wind control and permit the accumulation of snow and undisturbed litter beneath them insulate the ground. This means the ground warms slowly on a sunny day. This ensures that snow thaws later and more evenly in the spring. Spring perennials, including forsythia and early flowering bulbs, planted beneath such windbreaks will be well insulated against wind and subzero temperatures, but will bloom later in the spring.

It is also important to recognize that at a break in a wind barrier high pressure is released and the wind velocity increases above its open field velocity. This is known as the Venturi effect. For example, just past the edge of a moderately dense shelterbelt, wind speed is increased 10 percent above open field velocity. Also, because the foliage mass of a tree serves as a direct block to the passage of air, air movements directly beneath the leaf canopy may be accelerated. Therefore, careful placement of a windbreak is essential, and poorly placed windbreaks should be removed. Their growth should be carefully monitored to prevent the development of scrawny bare spots near the ground that encourage the acceleration of wind. If trees with high canopies are desired for a windbreak, fill in the bare spots beneath them with shrubs and bushes.

The Venturi effect may also be used to blow areas clear of snow and to provide snow-free parking areas, walkways, or roadways. Alternatively, plantings may be designed to channel winds and cause desirable snowdrifts and deposits on ski trails and toboggan runs.

Plants that block wind may also prevent heat loss by adding a layer of insulating air around a building. A hedge of yew (*Taxus* species) or privet (*Ligustrum vulgare*) adjacent to a wall will provide a pocket of dead-air space, insulating against heat loss.

In addition to obstructing, filtering, and deflecting winds, plant barriers may channel and accelerate beneficial breezes into defined areas. This strategy is desirable in warm climates when cooling breezes are needed. A funnel of trees or tall hedges that guides the prevailing winds can provide constant, natural "air

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DECIDUOUS TREES MODIFY TEMPERATURE OF BUILDINGS

By Robert L. Ticknor, Professor of Horticulture, North Willamette Experiment Station, Oregon State University, Aurora, OR

The following three papers were presented and discussed at the 1980 Ornamentals Northwest Seminars, August 24-26, in Seattle, WA.

It has been estimated that 32 percent of the energy used in the United States is for heating and cooling buildings occupied by people. One way of reducing this energy use is by climate modification through planting suitable trees around homes and other small structures.

Fuel Consumption

Fuel consumption is only half as much in a 3 mph wind at 32°F as with a 12 mph wind at 32°F. While a reduction of this magnitude is not possible with a limited wind break, a reduction of 40 percent in fuel consumption has been reported when shelter belts were planted on three sides of a dwelling. The effect extends for 20 times the height of the windbreak so in urban situations street trees and other landscape trees must contribute to fuel savings by reducing wind velocity. Temperatures downwind of a shelterbelt 3 to 4°F higher than upwind were found in Illinois which could be another of the factors contributing to reduced fuel consumption in winter.

Trees and Cooler Temperatures

Lower temperatures under and around trees during the summer is a widely observed phenomenon. Temperatures 10 to 20°F lower in the shade of a tree set up convection currents increasing the feeling of comfort in the shade. House trailers in an Alabama study were 104°F inside in full sun but only 80°F in the shade of trees.

This cooling effect is achieved two ways. Solar radiation is intercepted so less heating of interiors of houses, roofs, and the surrounding pavement takes place, reducing the need for fans or air conditioning to maintain comfort. The evaporative cooling effect of a fairly large tree transpiring 75 to 100 gallons of water a day is equivalent to five average sized air conditioners operating 20 hours per day.

Tree Placement

Trees on the east and west sides of a building can intercept the low angle rays of the sun which strike the windows at near a right angle at the beginning and end of the day causing maximum heat build-up within the building. They also reduce heat accumulation in the attic area by intercepting part of the solar radiation that strikes the roof.

A wide roof overhang prevents the summer sun ray from contacting the windows of a building from the south but does not prevent heat build-up in the attic area. This heat build-up in the attic radiates heat into the building below for hours after the sun goes down. Heat build-up can be prevented by planting deciduous trees on the south side of the house as well as the east and west sides. If solar collectors for water heating are planned, then trees should not be planted on the south side.

These two trees, Acer rubrum 'Red Sunset' (left) and Acer rubrum 'October Glory' show the difference in time of defoliation, the critical factor for a shade tree.

Foliation Season

Deciduous trees with a relatively short season in foliage are desirable in the cool cloudy western part of the Pacific Northwest where the period of bright sunshine and high temperature is short. East of the Cascades the sun is bright all summer so trees with a longer period in leaf are desirable.

Observations made in the Landscape Tree Trial at the North Willamette Experiment Station have indicated the period of foliation for over 150 species and cultivars. Trees that start to leaf out between February 26 and March 31, are considered early, while trees starting to leaf out after May 15 are classed as late. Table I shows the early and Table II shows the late foliating trees. The time of defoliation is the other factor that determines the length of the foliation season. Trees that are 100 percent defoliated before November 5, are considered early defoliators and are listed in Table III while those that defoliate after December 5, are considered late defoliators and are shown in Table IV. There is variation in the dates of these events from year to year but trees that generally fall within these dates are not listed. Of course a larger number of trees react between the extreme dates and are not listed in this report.

The average height and width in feet at planting after 5 and 10 years of most of the trees mentioned is shown in Table I. The trees were grown in a fertile, well drained soil without competition and received summer irrigation so the sizes may be larger than similar aged trees growing under less favorable conditions.

If we wish to shade a building, medium or large trees are needed but smaller trees can be helpful for blocking sunlight from a limited area like a window or patio. The trees in the tables are listed alphabetically regardless of size.

Trees that both come into leaf late (late foliators) and drop their leaves early (early defoliators) have a relatively short period during which they retain their leaf canopy: they are foliated to provide shade during the warmest summer months; it is important that a tree defoliate early in the fall so benefit can be derived from direct solar radiation striking the building or object previously shaded. The number of trees that come into leaf late, then drop their leaves early is limited to *Acer saccharum* 'Green Mountain' ('Green Mountain' Sugar Maple), *Tilia cordata* (Little Leaf Linden and the cultivars 'Greenspire'). Very close to this ideal are *Gleditsia triacanthos inermis* (Thornless Honey-locust) and several of its cultivars such as 'Rubylace,' 'Shademaster,' 'Skyline,' and 'Sunburst.'

The list of desirable trees is expanded considerably if trees which defoliate early are used regardless of their season of foliation. Late defoliating trees in Table IV are particularly undesirable for climate control since the temperatures are cooler and the sunlight is less in November and December than in April and

Continues on page 25

Table I

EARLY FOLIATION* TREES WHICH START TO LEAF OUT BETWEEN FEBRUARY 26 AND MARCH 31 IN THE LANDSCAPE TREE TRIALS AT THE NORTH WILLAMETTE EXPERIMENT STATION, AURORA, OREGON

Scientific Name	Common Name
Acer bueroerianum	Trident Maple
Acer ginnala	Amur Maple
Acer neguno	Box Elder
Acer rufinerve	Redvein Maple
Betula papyrifera occidentalis	Western Paper Birch
Betula platyphylla japonica	Japanese White Birch
Carpinus betulus fastigiata	Upright European Hornbeam
Cercidophyllum japonicum	Katsuratree
Cornus florida welchi	Welch Flowering Dogwood
Cornus nuttalli 'Goldspot'	Goldspot Pacific Dogwood
Corylus colurna	Turkish Hazel
Crataegus 'Autumn Glory'	Autumn Glory Hawthorn
Crataegus laevigata 'Crimson Cloud'	Crimson Cloud Hawthorn
Crataegus laevigata 'Paul's Scarlet'	Paul's Scarlet Hawthorn
Crataegus laevigata 'Winter King'	Winter King Hawthorn
Evodia danielli	Korean Evodia
Evodia henryi	Henry Evodia
Evodia hypehensis	Hupeh Evodia
Halesia monticola	Mountain Silverbell
Koelreutaria paniculata	Golden Raintree
Liquidambar orientalis	Oriental Sweetgum
Liriodendron tulipifera	Tulip Tree
Malus floribunda	Japanese Flowering Crabapple
Parrotia persica	Persian Parrotia
Phellodendron amurense	Amur Corktree
Prunus cerasifera 'Thundercloud'	Thundercloud Purple-Leaf Plum
Prunus sargenti columnaris	Columnar Sargent Cherry
Pterostyrax corymbosa	Little Epaulettetree
Pyrus calleryana 'Aristocrat'	Aristocrat Callery Pear
Pyrus calleryana 'Bradford'	Bradford Callery Pear
Salix alba tristis	Golden Weeping Willow
Salix babylonica	Weeping Willow
Sorbus alnifolia	Korean Mountainash
Sorbus aucuparia	European Mountainash
Sorbus aucuparia Cardinal Royal	Cardinal Royal European Mountainash
Stewartia pseupocamellia	Japanese Stewartia
Styrax japonicus 'Kusan'	Kusan Japanese Snowbell
Syringea reticulata	Japanese Tree Lilac
Ulmus pumila var arborea	Narrow Siberian Elm

*When first true leaf is visible.

Table II

LATE FOLIATION* TREES WHICH START TO LEAF OUT BETWEEN MAY 15 AND MAY 27 IN THE LANDSCAPE TREE TRIALS AT THE NORTH WILLAMETTE EXPERIMENT STATION, AURORA, OREGON

Scientific Name	Common Name
Acer pseudoplatanus	Sycamore Maple
Acer saccharum 'Green Mountain'	Green Mountain Sugar Maple
Acer saccharum 'Sweet Shadow'	Sweet Shadow Sugar Maple
Albizia julibrissin	Silk Tree
Chionanthus virginicus	Fringe Tree
Cornus florida rubra (Some Strains)	Red Flowering Dogwood
Diospyros kaki	Oriental Persimmon
Diospyros virginiana	American Persimmon
Fagus sylvatica atropunica	Purple European Beech
Gleditsia triacanthos 'Sunburst'	Sunburst HoneyLocust
Lagerstroemia indica	Crepe Myrtle
Liquidambar styraciflua (medium or late)	Sweet Gum
Liquidambar styraciflua 'Palo Alto'	Palo Alto Sweet Gum
Magnolia fraseri	Fraser Magnolia
Nyssa sylvatica	Black Gum
Quercus coccinea	Scarlet Oak
Quercus palustris	Pin Oak
Quercus phellos	Willow Oak
Quercus Robur Fastigiata	Upright English Oak
Rhus typhina	Staghorn Sumac
Tilia cordata	Littleleaf Linden
Tilia cordata 'Greenspire'	Greenspire Littleleaf Linden

*When first true leaf is visible.

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AVERAGE HEIGHT AND WIDTH IN FEET OF EARLY DEFOLIATING TREES AFTER 5 AND 10 YEARS IN THE LANDSCAPE TREE TRIALS AT THE NORTH WILLIAMETTE EXPERIMENT STATION

		Average Height			Average Width		
	E.M.H.*	At Planting	At 5 Years	At 10 Years	At Planting	At 5 Years	At 10 Years
Acer negundo	40/60	11.9	17.8	28.2	3.0	11.5	20.5
Acer negundo variegata	40/50	8.0	14.2	23.3	2.5	9.9	17.1
Acer platanoides 'Drummondi'	50/60	3.0	17.8	26.8	0.0	6.5	13.9
Acer platanoides 'Fassen's Black'	50/60	9.6	16.1	23.2	1.5	7.4	14.3
Acer platanoides 'Schwedleri'	50/60	7.5	16.6	24.6	0.9	8.8	21.9
Acer rubrum 'Autumn Flame'	40/50	6.3	15.6	27.4	1.1	12.5	25.8
Acer rubrum 'Bowhall'	50/60	5.2	20.6	32.6	0.8	5.8	9.8
Acer rubrum 'Scanlon'	50/60	10.8	22.8	34.4	2.6	6.0	11.2
Acer saccharum 'Green Mountain'	70/80	8.3	18.6	28.8	1.1	7.7	18.5
Betula maximowicziana	40/50	5.4	13.3	26.5	1.5	7.3	21.5
Betula papyrifera	70/80	6.0	19.3	30.9	1.9	8.5	15.7
Betula pendula gracilis	50/60	8.6	21.6	36.2	2.6	7.5	16.7
Cercidophyllum japonicum	40/50	4.0	13.6	23.2	2.6	7.0	14.2
Corylus colurna	50/60	7.5	16.2	18.3	2.5	9.4	13.3
Fraxinus pennsylvanica 'Summit'	50/60	6.9	13.1	20.7	0.0	5.6	12.0
Glenitsia triacanthos 'Rubylace'	40/50	3.6	9.2	17.9	0.0	9.5	19.9
Gleditsia triacanthos 'Shademaster'	60/70	4.9	12.1	26.9	2.0	10.6	20.1
Gleditsia triacanthos 'Skyline'	60/70	2.8	12.5	27.2	0.0	10.1	20.7
Gleditsia triacanthos 'Sunburst'	50/60	7.8	13.7	27.6	2.0	10.6	24.8
Nyssa sylvatica	40/50	2.8	7.3	17.3	0.8	6.5	12.7
Phellodendron amurense	30/40	1.5	10.9	22.4	0.5	8.0	21.2
Tilia americana	50/60	6.6	17.0	27.8	0.6	11.4	20.0
Tilia cordata	50/60	7.3	17.0	30.7	2.9	12.3	25.6
Tilia cordata 'Greenspire'	50/60	6.1	18.2	29.4	2.4	11.0	24.4

*Expected Mature Height in 30 to 40 years.

May. Also many of these late defoliating trees drop their leaves over a long period of time so that leaf raking becomes an endless chore.

Several Birch and Maples as well as other species which grow large enough to shade a building are found in Table II, the early defoliating trees. Although the Box Elder *(Acer negundo)* produces many seedlings, its variegated form doesn't seem to produce seedlings and gives a cool green effect. On the list are three forms of Norway Maple *(Acer platanoides* 'Drummondi' with green and white variegated leaves, 'Fassen's Black' with maroon leaves all season, and 'Schwedler' with red leaves early which become dark green later). *Acer rubrum* 'Autumn Flame' is a round headed tree which is usually the first tree to develop fall color and to defoliate each year. 'Bowhall' and 'Scanlon' are other early defoliating *A. rubrums* but have a columnar habit so are not good shade trees.

Two of the birch, *Betula papyrifera* (Paper Birch) and *B. pendula gracillis* (Cut Leaf European Birch) are fast growing tall trees but have a narrow habit so do not cast much shade. The *B. maximowicziana* (Monarch Birch) at the North Willamette Experiment Station is probably a hybrid but it does have a good rounded head and white bark.

Continues on page 26

Acer saccarum 'Green Mountain' Sugar Maple provides a relatively early fall color and defoliation which allows the sun's warming rays to penetrate through this tree.

Table III

EARLY DEFOLIATION* TREES WHICH DEFOLIATE BETWEEN OCTOBER 12 AND NOVEMBER 5 IN THE LANDSCAPE TREE TRIALS AT THE NORTH WILLAMETTE EXPERIMENT STATION, AURORA OREGON

Scientific Name	Common Name	Scientific Name	Common Name
Acer ginnala	Amur Maple	Diospyros virginiana	American Persimmon
Acer negundo	Box Elder	Fraxinus pennsylvanica 'Summit'	Summit Green Ash
Acer negundo variegatum	Variegated Box Elder	Gleditsia triacanthos inermis	Thornless Honey Locust
Acer platanoides 'Drummondi'	Drummond Norway Maple	Gleditsia triacanthos 'Rubylace'	Rubylace Honey Locust
Acer platanoides 'Fassen's Black'	Fassen's Black Norway Maple	Gleditsia triacanthos 'Shademaster'	Shademaster Honey Locust
Acer platanoides 'Schwedleri'	Schwedler Norway Maple	Gleditsia triancanthos 'Skyline'	Skyline Honey Locust
Acer rubrum 'Autumn Flame'	Autumn Flame Red Maple	Nyssa sylvatica	Black Gum
Acer rubrum 'Bowhall'	Bowhall Red Maple	Phellodendron amurense	Amur Cork Tree
Acer rubrum 'Scanlon'	Scanlon Red Maple	Prunus subhirtella 'Autumnalis'	Autumnalis Flowering Cherry
Acer saccharum 'Green Mountain'	Green Mountain Sugar Maple	Syringa reticulata	Japanese Tree Lilac
Asimina triloba	Paw Paw	Tilia americana	American Linden
Betula maximowicziana	Monarch Birch	Tilia cordata	Little-Leaf Linden
Betula papyrifera	Paper Birch	Tilia cordata 'Greenspire'	Greenspire Little-Leaf Linden
Betula pendula gracilis	Cutleaf European White Birch		
Cercidiophyllum japonicum	Katsuratree		
Cornus florida fastigiata	Upright Flowering Dogwood		
Corylus colurna	Turkish Hazel		

*Time of complete defoliation.

Table IV

LATE DEFOLIATION* TREES WHICH DEFOLIATE AFTER DECEMBER 5 IN THE LANDSCAPE TREE TRIALS AT THE NORTH WILLAMETTE EXPERIMENT STATION, AURORA, OREGON

Scientific Name	Common Name	Scientific Name	Common Name
Acer obtusatum		Liquidambar styraciflua 'Palo Alto'	Palo Alto American Sweet Gum
Betula pendula verrusoca	Clump European White Birch	Magnolia soulangeana	Saucer Magnolia
Carpinus orientalis	Oriental Hornbeam	Malus floribunda	Japanese Flowering Crabapple
Celtis sinesis	Chinese Hackberry	Ostrya carpinifolia	European Hophornbeam
Cercis silguastrum	Judas Tree	Parrotia persica	Persiam Parrotia
Cornus nuttalli 'Goldspot'	Goldspot Pacific Dogwood	Prunus cerasifera 'Thundercloud'	Thundercloud PurpleLeaf Plum
Crataegus 'Autumn Glory'	Autumn Glory Hawthorn	Pterostyrax corymbosa	Little Epaulettetree
Crataegus lavallei	Carriere Hawthorn	Pyrus calleryana 'Bradford'	Bradford Callery Pear
Fagus sylvatica atropunica	Purple European Beech	Quercus aliena	Oriental White Oak
Laburnocytisus adami	Adams Laburnocytisus	Quercus coccinea	Scarlet Oak
Laburnum alpinum pendulum	Weeping Scoth Laburnum	Quercus douglasi	Blue Oak
Laburnum Watereri 'Vossi'	Vossi Laburnum	Quercus lobata	Valley Oak
Liquidambar formosana	Chinese Sweet Gum	Quercus palustris	Pin Oak
Liquidambar formosana 'Afterglow'	Afterglow Chinese Sweet Gum	Quercus robur fastigiata	Upright English Oak
Liquidambar orientalis	Oriental Sweet Gum	Quercus shumardi	Shumard Red Oak
Liquidambar styraciflua	American Sweet Gum	Robinia ambigua 'Idahoensis'	Idaho Locust
Liquidambar styraciflua 'Burgundy'	Burgundy American Sweet Gum	Salix babylonica	Weeping Willow
Liquidambar styraciflua 'Festival'	Festival American Sweet Gum	Styrax japonica 'Kusan'	Kusan Japanese Snowball
Liquidambar styraciflua 'Gumball'	Gumball American Sweet Gum	Zelkova serrata 'Village Green'	Village Green Sawleaf Zelkova

*Time of complete defoliation

Several less common trees such as Katsura, Turkish Hazel, Black Gum, and Amur Cork Tree as well as Summit Green Ash and American Linden, are additional early defoliating trees. *Cercidophyllum japonicum* (Katsura tree) grows at a moderate rate, forming a medium sized tree with good fall color. *Corylus colurna* (Turkish Hazel) forms a medium to large pyramidal tree with edible nuts. *Nyssa sylvatica* (Black Gum) is a medium size tree with good fall color that tolerates wet soils but is difficult to transplant. *Phellodendron amurense* is a medium sized tree which produces filtered shade over a wide area. *Fraxinus Pennsylvanica* 'Summit' (Summit Green Ash) develops into a large upright oval tree. *Tilia Americana* (American Linden) grows into a large tree with large heart-shaped leaves producing dense shade.

Summary

Deciduous trees can reduce heating and cooling costs for home and other small buildings by intercepting solar radiation during the hot part of the year and letting it through during the cold season. Their transpiration provides evaporative cooling during the summer and their bare branches reduce wind velocity in the winter to lower heating costs. **WTT**

VEGETATIVE WINDBREAKS MAKE EXCELLENT HOME INSULATORS

By Donald Hanley, Extension Forester, University of Idaho, Moscow, ID

A windbreak is a vegetative or mechanical barrier that is designed to reduce or eliminate undesirable effects of strong winds. Mechanical barriers, constructed of slats or narrow boards with about 50 percent density in the upper two-thirds of its height and 25 percent density in the lower third, will normally reduce open wind velocities by 40 to 60 percent on the lee side zone lying between 3 and 10 times the barrier's height.

The main advantage of mechanical barriers is that they require little space and no waiting period for protection. However, the main disadvantage to mechanical barriers is that they can not be constructed very tall. About 6-10 feet in height is the maximum practical height, especially where there are heavy snow loads. Vegetative barriers, on the other hand, often grow 60-70 feet in height depending on the species used.

Because of the severe limitation to mechanical barriers such as height, anchoring, and cost, the rest of my remarks will address vegetative barriers. Windbreaks, then, I will define as vegetative barriers.

There are two basic types of windbreaks depending on their location and what they are protecting. The first is a farmstead windbreak. A farmstead windbreak is used to protect the main farmhouse or outbuildings from winds and snow drifts. The second main type is a field windbreak designed to protect crops and livestock for increased yields and better performance.

Windbreak Benefits

Probably the single most important benefit of a farmstead windbreak is the reduction of energy required to heat a home. Recent studies (4) of windbreaks show that windbreaks can reduce winter fuel consumption by 10 to 30 percent. For example, one study in Nebraska compared the fuel requirements of identical test houses which maintained a constant inside temperature of 70°F. The house protected by a windbreak used 23 percent less fuel.

Two identical electrically heated homes in South Dakota were compared for energy usage. One was sheltered by a farmstead windbreak and the other was not. Inside temperatures were maintained at 70°F. The sheltered home used 34% less electricity—quite a sizeable savings in today's energy market.

In addition to reducing the force of the wind, windbreaks also can reduce the wind chill impact on people outside the house.

Studies of three-row windbreaks, where trees were 25 feet tall, show that wind velocities and the wind chill index were effectively reduced (Figure 1).

Energy savings can be further enhanced by the use of foundation plantings (Figure 2). Trees and shrubs planted closely to buildings reduce wind currents. These foundation plantings create a "dead air" space which slows the escape of heat from a building. Please notice that deciduous plantings are made on the south and southwest sides of the home to block the sun in the summer, but allow the warming rays in the winter to come through.

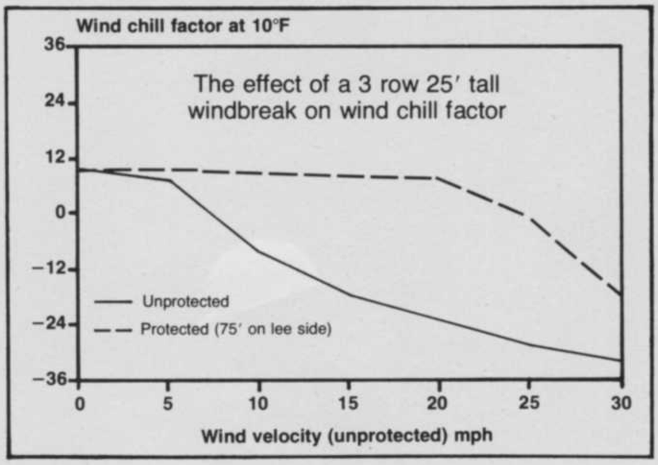

Figure 1

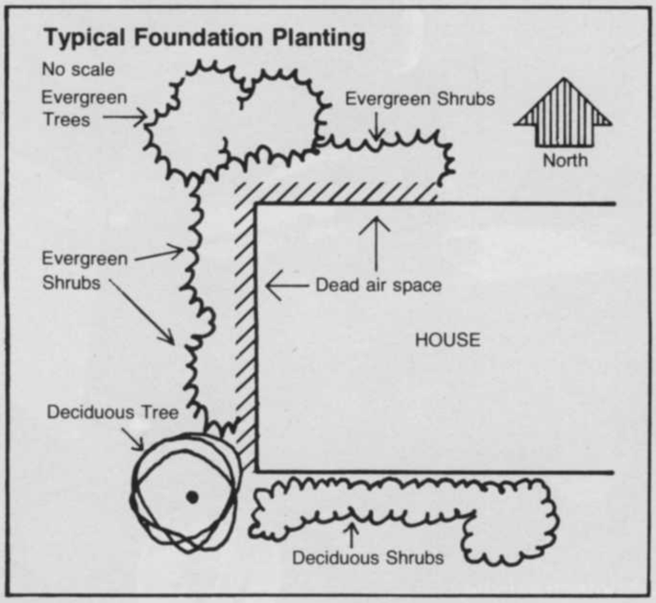

Figure 2

It has long been recognized that increased crop yields is a windbreak benefit. This data is variable, however. E. J. George (2) reports that a South Dakota study showed an increase in corn of 8-9 bushels per acre, while alfalfa increased ¾ ton per acre. In Idaho he reports potatoes increased by 80 bushels per acre. Some researchers attribute a portion of the yield increases to increased soil water penetration from snow drifts.

I have talked with numerous farmers in southern Idaho who have indicated to me that their crops "look better" in the leeward side of a windbreak. Unfortunately I know of no economic study that compares the benefits and costs of a windbreak.

Windbreaks provide improved habitat for small mammals and birds. A 1970 survey of 180 Idaho wind-

Continues on page 30

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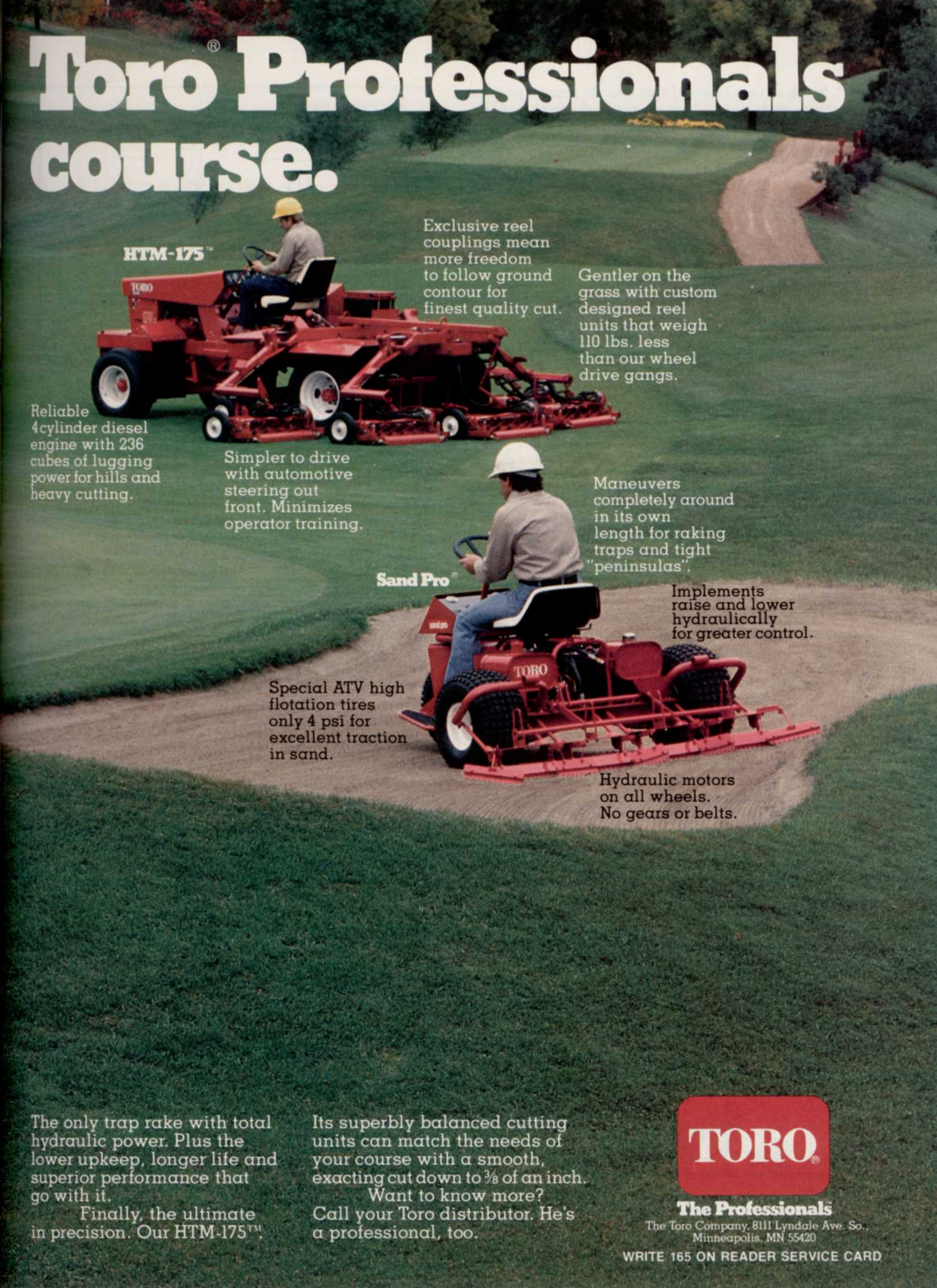
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break owners reported that over 30 percent of them were enthusiastic about the use of the trees by birds. The Idaho Fish and Game Department regularly plants windbreaks as nesting, brooding, and loafing areas for Chinese pheasants. The United States Forest Service is in the middle of a ten-year program to plant 75,000 Russian olive seedlings normally in southern Idaho on the Curlew National Grass Range for bird habitat. An excellent publication by Martel and Vohs (3), of Oregon State University, lists plants attractive to wildlife in the Pacific Northwest.

Windbreak Establishment

To survive and make satisfactory performance as a windbreak, young trees will need:

1. To be planted according to a sound plan.
2. A favorable climate and a suitable soil.
3. To be carefully handled and planted.
4. To have adequate moisture.
5. To be kept free of weeds.
6. To have protection from livestock and other damaging agents.

Windbreak planning is by far the most important step as the planning phase will determine the location, size (number of rows), tree spacing, and the tree species used.

In general, most settled areas below 5,000 feet elevation in this region have quite a favorable climate for growing windbreak trees. The lack of natural rainfall usually is not limiting because of modern irrigation practices.

However, a deep, well-drained loam soil with neutral pH and average fertility is ideal for growing a variety of trees. Species modifications will have to be made on sites with poor soils. In Idaho our major soil problems relate to iron, phosphorus, and zinc deficiencies, which are easily corrected with fertilization.

Location

Locate your windbreak at a right angle with the prevailing winds as nearly as possible. Figure 3 offers some suggestions on how windbreaks can be designed. Note how roadways cross the windbreak at non-perpendicular angles.

Place your windbreak about 100 feet from the house for maximum effectiveness. If you have considerable snow and wind in your locality, then locate your windbreak about 100-150 feet from buildings, driveways, or areas that need to stay free of drifts (Figure 4). A windbreak planted closer than 60 feet to the house or other main areas of the farmstead will be somewhat of a hindrance in snow country because of the deposition of the snow.

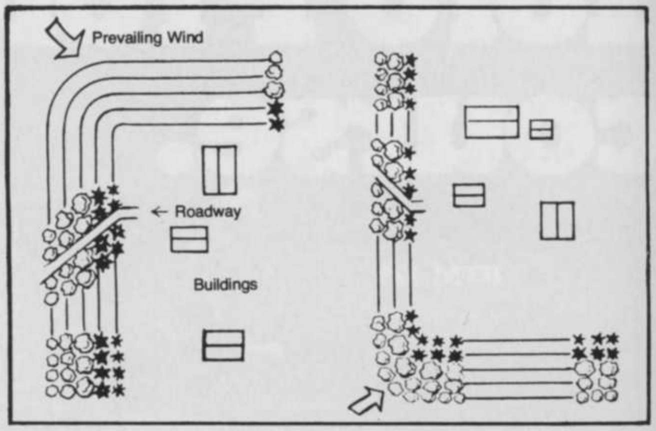

Figure 3

Extend your windbreak at each end 50 feet beyond the boundaries of the farmstead.

The location of a field windbreak will have to conform to maximum expected wind velocity, field boundaries, irrigation systems, power lines, roads, and soil type.

In this region, fields that are subject to severe wind erosion may require multiple-row planting along the windbreak border, supplemented by parallel single-row plantings at intervals of 500 feet or less (Figure 5). The usual velocity of erosive winds in your locality and the nature of your soil will determine the best intervals to use between the supplemental plantings. If the usual maximum wind velocity in your locality exceeds 30 miles per hour and you have light soils, place the supplemental windbreaks 350 feet apart. Under less severe conditions, tall trees in single-row plantings spaced 600 feet to ¼-mile apart will give adequate protection.

Windbreak size (number of rows)

My recommendation on windbreak size is to establish a five row windbreak whenever possible (Figure 6). Most owners that are contemplating the establishment of a windbreak are doing so because they have a wind problem. Five rows give the best protection.

If limited space prevents your planting a five-row windbreak, then use fewer rows rather than crowding your trees. Crowding trees in a windbreak causes a loss of vigor due to severe competition among the trees as they grow to mature size. Crowded trees slow down in growth and stagnate—reach a point where they make almost no growth—at an early age. The planting becomes more susceptible to wind whipping injuries and losses from insects, diseases, and drought. Lower limbs die out early from too much shade in an over-

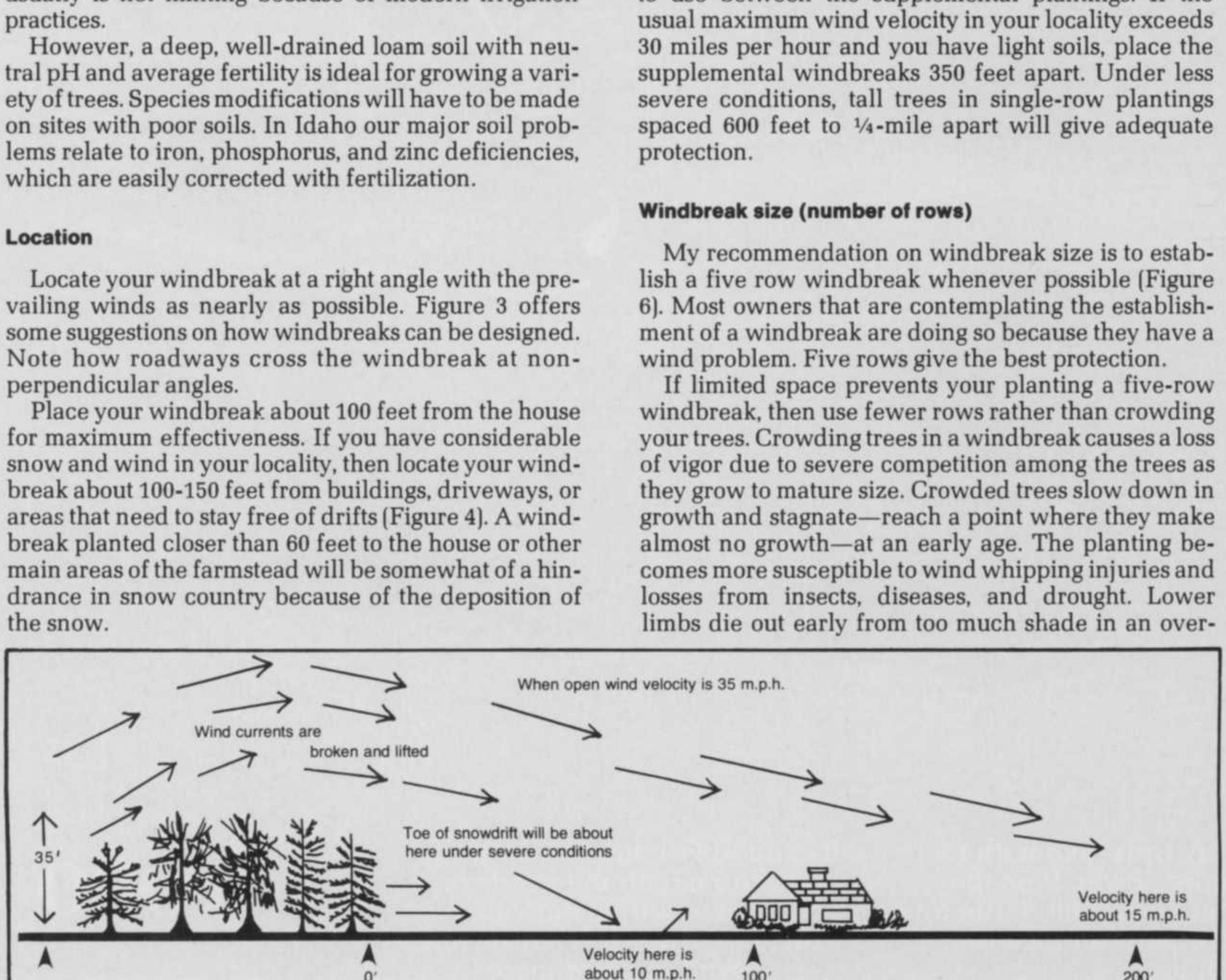

Figure 4