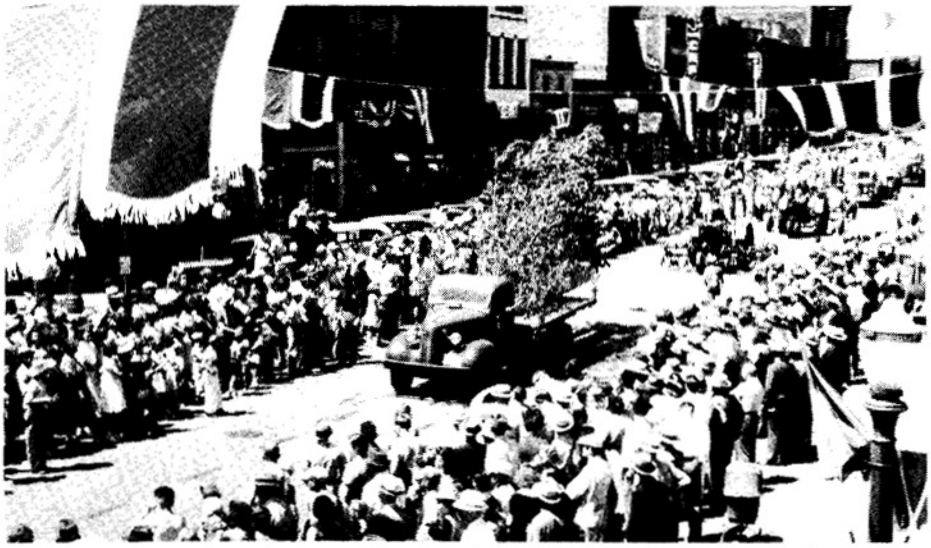
Inside Agroforestry
Rocky Mountain Forest & Range Experiment Station
National Agroforestry Center
Fall, 1995


A forest service truck carries trees taken from late 1930's Great Plains shelterbelt plantings in an early 1940's parade, proclaiming that trees actually do grow on the Plains and can "tame," the Great American Desert.

The Biggest Windbreak Project — Ever!

It was around 1932 that some fellow in Washington D.C. spun a grand dream of planting a belt of trees a hundred miles wide, stretching straight across the plains from Canada to Texas. Lots of people thought that towns would actually be moved to make way for this mighty forest, which at first grew only in the Washington fellow's mind...but grow it did!

Officially called the Prairie States Forestry Project, President Roosevelt initiated the idea early in the summer of 1934, and it was created by executive order on July 21st of the same year. (Some have actually credited President Roosevelt with originating this idea). A decade of decreasing agricultural income, prolonged drought, a series of duststorms, and finally economic collapse in the wheat and corn belts prompted the project. The purpose was to plant shelterbelts on the Plains, to an extent and degree sufficient to have some measurable effect on the physical conditions of the area. Through tree planting, the project's main purposes were to: ameliorate drought conditions, protect crops and livestock, reduce dust storms, and provide useful employment for drought-stricken people. This was the same project that some foresters, botanists, ecologists, and other scientists damned in no uncertain terms. The 1942 *Journal of Forestry* quoted a few of these comments in retrospect:

"A project which seems to me to be

(See Project on page 7)

Windbreaks in Sustainable Agriculture Systems

The term "sustainable agriculture" was introduced in the early 1980's and has since gained wide recognition. This term is used to convey the concepts of a system which balances whole-farm resource management with whole-farm productivity to meet the needs of people. The overall level of achieved productivity under a sustainable agriculture system is dependent upon the ability to coordinate and manage soil, water, plant, and animal resources simultaneously, within climatic and economic constraints. The type and number of plants and animals supported by the system are important and play significant roles, both individually and collectively in maintaining a healthy farm environment. Basically, sustainable land use could be considered as that which results in production of goods and services for the present generation without causing a decline in welfare of future generations

When designing a sustainable land-use system, decisions must be made as to "what" is to be sustained, and "for whom" is it to be sustained.

(See Sustainable on page 2)

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Message From the Manager

A commentary on the status of agroforestry as reported by Program Manager, Bill Rietveld

A New Partnership

We are pleased to announce that the National Agroforestry Center (NAC) is now a partnership of the USDA Forest Service (FS) and the USDA Natural Resources Conservation Service (NRCS). The partnership expands the Center's outreach in agroforestry research and development, technology transfer, and international technology exchange. In addition, the US Agency for International Development (USAID) will be providing initial support for NAC's International Technology Exchange program.

"An important part of our role as a pioneering program is to break barriers and build bridges."

——Bill Rietveld

This new partnership will add six people who will be affiliated with the Center. NRCS will assign three agroforesters to work full-time with the Center. One will be located at NAC in Lincoln, one will be located at NRCS's new Watershed Sciences Institute in Seattle, and one will be located at NRCS's Grazing Land Technology Institute in Fort Worth, Texas. In addition, NRCS will locate two scientists at NAC, one from their Watershed Sciences Institute, and one from their Wetlands Science Institute (which is located in Laurel, Maryland). The sixth person will be an International Coordinator, who will be funded for a two-year trial basis through an agreement among FS, NRCS, and USAID.

Interest in agroforestry is rapidly expanding, nationally and internationally. Earlier this year, the Center expanded its scope and changed its name in response to this increasing interest. Now we have taken another step to make the Center more responsive to the needs of agroforestry and its customers. The new interagency partnership will work through cooperation with a national (and international) network of agencies, universities, and organizations to accelerate the development and application of agroforestry technologies.

We believe this is the appropriate model for the 21st century — develop teams and leverage limited resources to accomplish shared goals. Agroforestry is ideally positioned for interagency cooperation and teamwork because it is inherently cross-cutting — it crosses discipline and agency boundaries. An important part of our role as a pioneering program is to break barriers and build bridges. We have many challenges ahead. The ball is in our court, and we are determined to make it a success story. We will provide updates on this and other developing partnerships in future issues of *IA*.

(Sustainable from page 1)

Terms such as "production agroforestry" and "conservation agroforestry" place emphasis on "what" is to be sustained and to some extent, these terms also imply "for whom." Often times individual farmers are more often in the business of sustaining productivity, while other parts of society may focus on sustaining environmental benefits. An agroforestry system should, by design, provide both environmental and productivity benefits; in fact, they cannot produce one without the other in almost all instances.

Windbreaks are a good example of an agroforestry technology that sustainably provides both production and conservation attributes, while producing wood products, wildlife habitat, and increasing crop yields. Strategically located and properly designed, they can increase livestock weight gain by as much as 10 percent, while at the same time, those same livestock will require significantly less feed. And, during severe weather years, tree windbreaks have increased crop productivity by as much as 33 percent. Alfalfa yields have increased by 12 percent and native tall grass yields by 100 percent! Furthermore, windbreaks can cut heating and cooling costs for homes by as much as 30 percent.

Yes, windbreaks, as well as other tree and shrub planting combinations, have an important role to play in today's integrated agricultural systems. In the future, these systems will help reduce human impact on resources, while at the same time provide sufficient supplies of high quality food and fiber. Trees and shrubs planted as windbreaks provide wind erosion control, improve crop yield, and enhance the quality of many wind-sensitive crops. Finally, windbreaks add beauty to the landscape and increase the value of the land — all contributing to a healthier, more pleasant sustainable ecosystem.

Sources: "Windbreaks in Sustainable Agricultural Systems" by Vernon C. Quam and John Gardner, NDSU, James R. Brandle and Teresa K. Boes, UN-L; and "Role of Agroforestry in Sustainable Land-Use Systems" by K.N. Brooks, H.M. Gregersen, and P.F. Ffolliott in Agroforestry and Sustainable Systems: Symposium Proceedings, August, 1994.

Windbreaks For All Seasons and Reasons

by Bruce C. Wight, National Agroforester, USDA Natural Resources Conservation Service, Lincoln, Nebraska

Windbreaks have been a key agroforestry practice for at least the past 100 years in the United States and continue to be probably the most widely used agroforestry practice. As noted elsewhere in this newsletter, windbreaks have a long history. Hedges were used in Europe as far back as the English Tudors in the 1600's.

How widespread have windbreaks been applied in the United States? According to the 1987 USDA Natural Resources Conservation Service (NRCS) National Resources Inventory (NRI), windbreaks comprise a substantial resource with windbreaks being identified in 40 of the 50 states. From protecting blueberries in Maine to controlling drifting sand in California, and from protecting grain crops in North Dakota and Minnesota to providing cover for wildlife in New Mexico and the Texas panhandle, windbreaks are providing many benefits. The tree species used are as diverse as the geographic regions from alder protecting orchards in New York to ponderosa pine protecting livestock in Nebraska to Rocky Mountain juniper stopping snow in Colorado and Wyoming to 'Tropic Coral' protecting flower crops in Hawaii. A person traveling across the country can find a use for a windbreak in just about every state. The region with the least number of windbreaks is the Southeast probably due to the abundance of forest land. However, even in the Southeast there are opportunities for windbreaks such as crop protection on sandy soils.

Windbreaks have traditionally been used to protect soil, plants, animals, and people from adverse winds. The term windbreak is often used interchangeably with shelterbelt. The NRCS considers a windbreak/shelterbelt to be a linear planting of trees or shrubs established for environmental purposes. These types of tree and shrub plantings are used to meet a variety of purposes including reducing wind erosion, protecting growing plants, managing snow, providing shelter for structures and livestock, providing wildlife habitat, providing a tree or shrub product, providing living screens, improving aesthetics, and improving irrigation efficiency. The most commonly planted windbreak types include farmstead windbreaks and field windbreaks.

Landowners recognize the value of a farmstead windbreak. In fact, it is usually the first windbreak planting opportunity for most farmers or ranchers. A farmstead windbreak provides a number of benefits to the owner. Some of these benefits can be easily translated into dollars such as a 10 to 30 percent reduction in energy costs, increased property values, reduced snow removal, lower feed costs for livestock, or less physical wind damage to buildings. Other benefits are less tangible including reducing noise, improving animal health, screening unsightly areas and improving working conditions. Even though the term farmstead windbreak is used, a windbreak can be used to protect any structure ranging from industrial buildings to the suburban home. In a North Dakota subdivision, windbreaks were planted around two to three acre lots before the first lot was sold. The subsequent selling prices were higher than those in adjoining subdivisions without trees.

Field windbreaks can provide wind protection and other microclimatic changes to adjacent fields resulting in improved crop quality and quantity. They can also serve as buffer strips to help improve water quality and add wildlife habitat. Field windbreaks provide a variety of benefits to adjoining fields and crops including increasing crop production from 6 to 44 percent, reducing wind erosion from 50 to 100 percent, improving irrigation efficiency, and managing the moisture from snow more effectively. Field windbreaks have changed significantly from the ten row windbreaks of the 1930's to narrow one and two row windbreaks of today.

What does the future hold for this "old" agroforestry practice? Nationwide we have seen a gradual decline in the number of windbreaks planted and the condition of those remaining. The NRI shows about a four percent decline for field windbreaks and about a two percent loss

(See Seasons on page 7)

Table 1 — Windbreaks in the United States

Windbreaks	Number	Acres	Miles
Farmstead	508,485	766,329	59,540
Field	349,672	599,116	116,031
Total	858,157	1,365,445	175,571

National total of farmstead and field windbreaks from the 1987 National Resources Inventory.

In this aerial view of field and farmstead windbreaks, it's clear that this North Dakota windbreak system was well-thought-out prior to building the housing development.

Windbreaks "Working" For Communities

This small community is fortunate to have a windbreak protecting its residents and is typical of what the Prairie Country RC&D is encouraging.

It hasn't taken long for rural community leaders in west-central Minnesota to catch on to the benefits of the windbreaks that the Prairie Country Resource Conservation & Development (RC&D) Council began promoting in 1992.

In fact, it's easy to see the many benefits. First and foremost, there's energy conservation (the main purpose of the windbreaks), and the advantage of lowering snow removal costs. Other benefits include education, recreation, and aesthetics.

It all started when the Prairie Country RC&D Council's Forestry Committee saw a need to plant windbreaks around rural communities, which are mostly surrounded by large expanses of cropland. The idea was a hit and they've been promoting them ever since.

"We're just taking traditional rural applications of windbreaks and applying them to communities," says Randy Nelson, Coordinator for Prairie County RC&D, in Willmar, Minnesota. "Picture a small rural community located in the middle of corn and soybean country. Adjacent farmers generally farm right up to the edge of town. Once crops are harvested and the ground tilled, large expanses of barren ground remain. Often times the first obstacle encountered by wind and windblown snow is the unprotected community." Nelson says that basically these windbreaks, usually located on the north and west sides of town, protect the community in much the same way a field windbreak protects a crop or pasture or a farmstead windbreak protects a homestead.

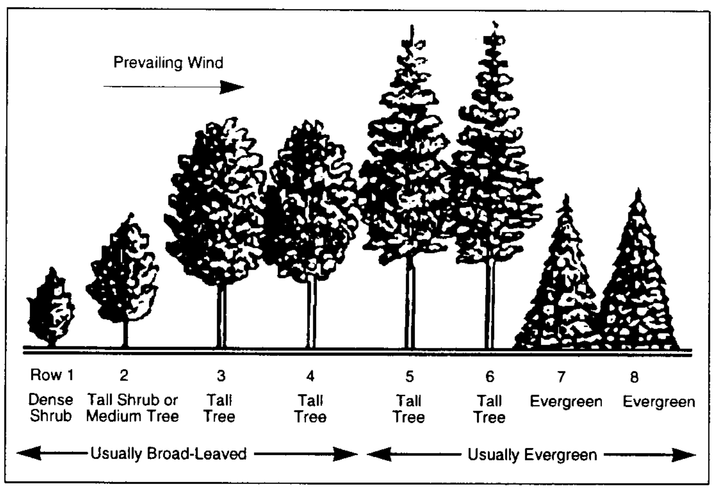
Initially, the Council asked area Soil and Water Conservation Districts (SWCD's) to speak with all of the communities in their county. And, once several windbreaks were established in strategically located high visability areas, the good word spread. Now, town leaders are contacting the Council about windbreaks! Currently five windbreaks have been planted with four more in the planning stage.

Most of the participating and interested communities are fairly small in size and consist of as few as 100 people to around 4,000 or 5,000 people. Thus far, the biggest problem for these communities, who lack the financial resources to put a project this size on the ground, has been locating cost-share funding. Almost 30 communites throughout the nine-county Prairie Country area are now interested in seeking funding to put a windbreak around their town. The main cost of the windbreak is actually acquiring the land from area farmers. This prime bean and corn farmland can sell for $800 to at least $2,000 per acre! Several proposals have been submitted to local power companies, many of whom have an interest because of the energy conservation component.

The Council relies on the local SWCD to assist with design and species recommendations. Most of the windbreaks are made up of multiple rows consisting of evergreens, deciduous trees, and a trip row comprised of shrubs. Typically, volunteers donate a great deal of in-kind services like preparing the site, planting trees, or helping out with maintenance.

Nelson feels that the potential is almost endless. "Once the concept catches on, and more windbreaks are installed, the community windbreak concept is sure to mushroom."

New and innovative ideas like this take the initiative of people like Randy Nelson, the Prairie Country RC&D Council and their cooperators. Thank you, keep up the good work!



Profile of a standard eight-row windbreak plan. The Prairie Country RC&D generally follows a variation of this concept: shrub row(s), tall tree row(s), with evergreens rows on the inside.

Just How Does A Windbreak Work?

Windbreaks are barriers used to reduce and redirect wind. They usually consist of trees and shrubs, but may also be made up of perennial or annual crops and grasses, fences, or other materials. The reduction in wind speed behind a windbreak modifies the environmental conditions, or microclimate, in the sheltered zone.

As wind blows against a windbreak, air pressure builds up on the windward side (the side towards the wind), and large quantities of air move up and over the top or around the ends of the windbreak.

Windbreak structure — height, density, number of rows, species composition, length, orientation, and continuity — determine the effectiveness of a windbreak in reducing wind speed and altering the microclimate.

Windbreak height (H) is the most important factor determining the downwind area protected by a windbreak. On the windward side of a windbreak, wind speed reductions are measurable upwind for a distance of 2 to 5 times the height of the windbreak (2H to 5H). On the leeward side (the side away from the wind), wind speed reductions occur up to 30H downwind of the barrier. For example, in a windbreak where the tallest trees are 30 feet, lower wind speeds are measurable for 60 to 150 feet on the windward side, and up to 900 feet on the leeward side! Within this protected zone, the structural characteristics of a windbreak, especially density, determine the extent of wind speed reductions.

Windbreak density is the ratio of the solid portion of the barrier, to the total area of the barrier. Wind flows through the open portions of a windbreak. Thus, the more solid a windbreak, the less wind that passes through. Low pressure develops on the leeward side of very dense windbreaks. This low pressure area behind the windbreak pulls air coming over the windbreak downward, creating turbulence and reducing protection downwind. As density decreases, the amount of air passing through the windbreak increases, moderating the low pressure and turbulence, and increasing the length of the downwind protected area. While this protected area is larger, the wind speed reductions are not as great. By adjusting windbreak density different wind flow patterns and areas of protection are established.

The number of rows, the distance between trees, and the species composition are contributing factors to windbreak density. When designing a windbreak, density should be adjusted to meet landowner objectives. A windbreak density of 40 to 60 percent provides the greatest downwind area of protection and provides excellent soil erosion control. To get even distribution of snow across a field, densities of 25 to 35 percent are most effective, but may not provide sufficient control of soil erosion.

Windbreaks are most effective when oriented at right angles to pre-

(See Windbreak on page 6)

Table 1 — Windspeed reductions to the lee of windbreaks with different densities. (H = mature tree height of the tallest tree row).

Open Wind speed 20 mph Deciduous 25-35% Density					
H distance from break	5H	10H	15H	20H	30H
mph	10	13	16	17	20
% of open wind speed	50%	65%	80%	85%	100%

Open Wind speed 20 mph Conifer 40-60% Density					
H distance from break	5H	10H	15H	20H	30H
mph	6	10	12	15	19
% of open wind speed	30%	50%	60%	75%	95%

Open Wind speed 20 mph Multi-row 60-80% Density					
H distance from break	5H	10H	15H	20H	30H
mph	5	7	13	17	19
% of open wind speed	25%	35%	65%	85%	95%

Open Wind speed 20 mph Solid Fence 100% Density					
H distance from break	5H	10H	15H	20H	30H
mph	5	14	18	19	20
% of open wind speed	25%	70%	90%	95%	100%

Snails May Save Chestnuts

There is renewed interest in utilizing chestnut trees in alley cropping practices in the east. However, chestnut blight has deterred using this species. At the start of this century over 4 million chestnuts graced the woodlands of eastern United States. By 1950, 99.9 percent fell victim to a deadly fungus. Today, researchers at the College of Environmental Science and Forestry at Syracuse, New York, are optimistic they are on the threshold of successfully breeding a blight resistant strain of the American Chestnut. They are pinning their hopes largely on genetic engineering and a fungus-eating snail called *Helix pomatia,* the same one epicures eat as escargot. The genes and enzymes of the snail's digestive tract hold the secret to what causes anti-fungal activity in the snail. By isolating a small protein that keeps fungal spores from germinating, it may be possible to break the genetic code. Then, by introducing the resistant protein into chestnut cells and growing the cells into a full tree, the hope is that the tree will have its own built-in defense system against the fungus that causes the death of chestnuts.

Source: Adapted from Arbor Day, May/June, 1994.

(*Windbreak from page 5*)

"Properly planned windbreaks can create changes in the microclimate and can be used to create desirable environments."

vailing winds. The purpose and design of each windbreak is unique, thus the orientation of individual windbreaks depends on the design objectives. Farmsteads and feedlots usually need protection from cold winds and blowing snow or dust. Orienting these windbreaks perpendicular to the troublesome winter wind direction provides the most useful protection. Field crops usually need protection from hot, dry summer winds and abrasive, wind-blown soil particles, or both. The orientation of these windbreaks should be perpendicular to prevailing winds during critical growing periods.

Although the height of a windbreak determines the extent of the protected area downwind, the length of a windbreak determines the amount of total area receiving protection. For a maximum efficiency, the uninterrupted length of a windbreak should exceed the height by at least 10:1. This ratio reduces the influence of end-turbulence on the total protected area. The continuity of a windbreak also influences its efficiency. Gaps in a windbreak become funnels that concentrate wind flow, creating areas on the downwind side of the gap in which wind speeds often exceed open field wind velocities. Where there are gaps, the effectiveness of the windbreak is diminished. Lanes or field accesses through windbreaks should be located at an angle to minimize this effect or, avoided all together if possible.

The reduction in wind velocity behind a windbreak leads to a change in the microclimate within the protected zone. Many benefits result, including an increase in temperature and humidity levels, which decreases evaporation of soil moisture and plant water loss. Actual temperature modifications for a given windbreak depend on windbreak height, density, orientation, and time of day. Also, soil temperatures in sheltered areas are usually slightly warmer than in unsheltered areas. Taking advantage of these warmer temperatures may allow earlier planting and germination in areas with short growing seasons.

Properly planned windbreaks can create changes in the microclimate and can be used to create desirable environments for growing crops, raising livestock, and protecting the living and working areas.

Source: Adapted from "How Windbreaks Work" by James R. Brandle, University of Nebraska and Sherman Finch, Natural Resources Conservation Service.

Field Windbreaks Increase Wheat Yields in 1995

Wheat yields at the Univeristy of Nebraska-Lincoln research and development facility near Mead, Nebraska showed significant yield differences depending upon the amount of protection fields received from windbreaks. The windbreaks did exactly what they were supposed to do in extreme years, like 1995. Exposed plots without any wind protection had many empty heads and showed extensive lodging. Crops in the sheltered plots really looked good.

Exposed Plots

Plot Number	Total Yield (bu)	Acres	Per Acre (bu)
1	170.0	8.5	20.0
2	116.0	7.4	15.6
3	74.0	3.0	24.8
4	77.5	3.0	25.8
5	176.0	4.8	36.6
6	157.0	5.0	31.4
7	50.5	1.85	27.3

Average yield 25.9 (+ or-) 6.9

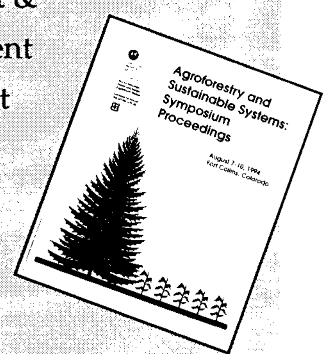
Sheltered Plots (Windbreaks on the west, south, and east) adjusted per acre yield includes acres given to windbreaks.

Plot Number	Total Yield (bu)	Acres	Per Acre (bu)	Adj. Per Acre
1	221.0	4.0	55.2	49.1
2	200.5	3.8	52.8	46.6
3	213.3	4.0	53.3	47.4
4	217.6	4.0	54.4	48.3

Average yield 53.9 (+ or -) 1.1

Average yield based on adjusted acres 47.4 (+ or -) 1.3

Proceedings now available from the *Agroforestry and Sustainable Systems* Symposium. For a free copy, contact Dick Schneider at the USDA Forest Service, Rocky Mountain Forest & Range Experiment Station, 240 West Prospect Road, Fort Collins, Colorado 80526 or call 970-498-1719.



(*Project from page 1*)

doomed to failure before it is started."

"The plan is fantastically impossible."

"By any fair appraisal it will be less than a 20 percent success."

"The whole enterprise, prominent as it is in the public mind, bids fair to prove a boomerang which will give forestry a terrific setback in public opinion."

However, to John L. Emerson, State Director of the Federal Forestry Service in 1935, it was absurd that there could have been any doubt about the shelterbelt's value. "Housewives know that their clothes dry faster in the wind," he said, "so why shouldn't the same thing apply to the soil? If we can keep the wind off, we can save the soil by helping it to retain mositure."

And, Carlos G. Bates, senior silviculturist for the US Forest Service in 1934, said this about the proposed project in the November, 1934 *Journal of Forestry*: "It is not an undertaking in which slip-shod methods will succeed; it represents a challenge to the technical skill of the profession and will require that our coming foresters develop a technical skill and a love for the soil which has not been much in evidence in the past."

Between 1935 and 1942, more than 200 million trees and shrubs were planted in windbreak strips on 30,000 individual farms in a patchwork pattern, totalling 18,600 miles in length. To the amazement of many, a great number of the original shelterbelts still remain! These windbreaks were a major factor in taming the harsh conditions that exist on the prairie and were directly responsible for making the Plains region what it is today...a productive agricultural region and a unique place to call home for millions of people.

Representative Jed Johnson of Oklahoma, a previous critic of the program, had a statement printed in the 1941 *Congressional Record* that said, "The Prairie States Forestry Project has proved to be a fully practical and extremely beneficial aid to agriculture in the plains country."

It's interesting to read through old literature from the 1930's and 1940's. Even then, professionals were quite aware of the benefits of trees: wind control, soil control, moisture retention, etc. Granted, not much research had been done to prove these benefits. But, the evidence was there.

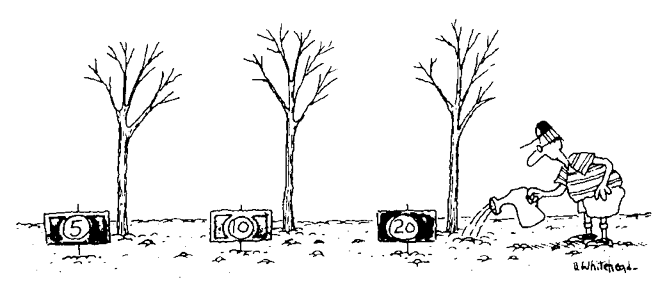
What research is telling us today is that windbreaks are effective in variable climate areas like the Plains. However, the Plains are certainly not the only place that windbreaks can be effectively applied. Scientists have found that they are applicable in all parts of the country, and for many purposes. Of course the most traditional applications like field and farmstead windbreaks are still popular. But, now variations of windbreaks are used to help control air pollution, deposit snow evenly across a field, protect livestock, reduce heating and air conditioning bills, and help keep major roadways and parking lots clear of snow...and the list goes on. Furthermore, almost every state in the union has windbreaks employed in one form or another. Take for example, Montana, where a windbreak is protecting a grade school and providing an outdoor laboratory for students. In Washington State, windbreaks are protecting apple orchards. New Mexico, a low precipitation zone, has windbreaks planted to distribute snow across agricultural fields providing extra soil moisture in the spring. And, of course, we can't forget those field windbreaks located where it all started — in North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, the new ones, the renovated ones, and the ones planted in the 1930's, that are still working today...after 60 years!

Source: Adapted from, "Journal of Forestry," November, 1934 and June, 1942; and "The Myth of Tree Planting on the Great Plains" by Martha Jean Williams Ferrill.

(*Seasons from page 3*)

for farmstead windbreaks. A survey of the key windbreak states in the Great Plains also showed that 60 to 80 percent need some type of renovation. This renovation may be as simple as removing sod from the windbreak, to releasing the trees by thinning, to total removal and replacement. A person may wonder why this decline is occurring. There are no easy answers but a large percentage of the existing windbreaks are over 60 years old and reaching the end of their natural life. Other reasons include changes in agricultural production methods such as larger equipment leading to larger fields and greater use of herbicides which can be detrimental to the adjoining windbreaks.

In my mind, the positive windbreak benefits far outweigh the negatives. Windbreaks can increase "profits" for clients and society, reduce resource problems and costs, create biodiverse habitats for humans and wildlife, and enhance local ecosystems. The "bottom line" for the agroforestry resource professional is to prove to the American landusers that windbreaks can improve their "bottom line" and help society, too. With increased interest and help by landowners and resource professionals, landscapes with few trees and shrubs can be transformed into multiple species and practices that can enhance the farms, families, and future of the nation.



IRVING HIPPLE CONDUCTED EXPERIMENTS TO SEE IF MONEY ACTUALLY COULD GROW ON TREES.