making our lives more pleasant—plants as climate changers

PLANTS CAN MAKE our lives more pleasant. Besides beautifying our surroundings, plants can modify the climate. They don't modify it very much, mind you, but the little that they do can be felt immediately. Ever sit under a shady tree on a hot day? Or walk in the woods when the wind is blowing across open fields hard enough to make you squint your eyes? It's cooler under the trees and the wind doesn't blow nearly as hard in the woods as it does in the open.

Trees and shrubs can modify the climate in other ways, too. They can increase the humidity and they can dampen the movement of hot air from busy highways. They can control the drifting of snow in winter, and they can be the umbrella that protects you from a sudden summer shower.

To understand climate—and the way plants modify it—you should know about the earth's energy balance. The earth as a whole—its land, water, and air—is a great machine, and its fuel is solar energy. Each 24 hours the sun showers the earth with energy equivalent to that obtained by burning 5½ billion tons of coal. How the earth stores, transports, converts, and spends this energy determines our climate.

About 30 percent of the solar radiation that reaches the outer limits of the earth's atmosphere is reflected back into space; about 20 percent is absorbed by the earth's atmosphere; the remaining 50 percent is absorbed by the earth's land and water surfaces.

The total amount of heat absorbed by the earth is balanced by the heat lost through infrared and longwave radiation. Over an extended time, the two balance or else the world would gradually become hotter or colder. Recent measurements made by satellite have confirmed that the global temperature does remain fairly stable. This balance is called the energy balance or, sometimes, the energy exchange.

To modify climate, then, requires that the rate at which this energy is exchanged be slowed down or speeded up. Trees and shrubs can do this. Of course, the height, volume, and density of a plant strongly influence the extent of any effect it has on its immediate surroundings. A pansy may provide plenty of shade for an ant, but a man needs a tree or a large shrub.

Consider a grove of trees and its effect on its surroundings. Viewed from above, the grove will look like a leafy, green canopy covering the ground. About 90 percent of the solar energy received by a grove is absorbed by the topmost foliage. Of course, this energy raises the temperature of the foliage. The foliage then radiates this heat outward in the same way that heat spreads outward from a hot stove or radiator. This outward radiation of heat reduces by a significant amount the temperature we feel when we stand in the grove.

Trees do a better job of reducing the temperature than would a tent or umbrella covering the same area. This is because a tree has depth of foliage. That depth gives the tree five to seven times as much absorbing surface as an umbrella or tent.

Probably you always thought it was perspiration, but a scientist would elaborate. He'd call it the exchange of

---

Author RAYMOND E. LEONARD is a meteorologist in the Northeastern Forest Experiment Station, Forest Service, at the State University of New York, Syracuse.

Trees and shrubs protect homes against wind in Nebraska (top) and North Dakota.

energy between people and the environment. And he'd tell you that it goes on continually. Normally, because of our high body temperatures, we emit more radiant energy than we receive from the surrounding atmosphere; so the process of energy exchange is a cooling one. Under clear skies, incoming longwave radiation is small; at night, when solar radiation is not present, cooling of an outdoor exposed surface is rapid.

So here's another way trees modify the climate. They act like a blanket to decrease the longwave radiation cooling of objects—and people—beneath them. Night temperatures are higher under trees than in the open. Also, the frost-free period is longer under trees than in the open. While a tree may act like a blanket at night, during the day it is nature's own air conditioner. And this is where it has its greatest effect on the climate.

Trees move moisture from the soil to the atmosphere. Absorption of solar energy by the canopy sets up the process known as transpiration. During transpiration, vast amounts of moisture from the ground move upward through the plant stem to the surface of the leaves. The moisture then evaporates from the leaf surfaces into the atmosphere.

The transpiration process uses a large part of the solar energy absorbed by the canopy, thus removing this possible heat load from the area beneath the canopy. Water vapor carries away into the atmosphere about 580 calories of heat for

each gram evaporated. A calorie is the amount of heat it takes to raise the temperature of 1 gram of water 1 degree centigrade.

Although measuring the effect of plants on air temperature exactly is fraught with complications, some assumptions can be made. I estimate that the overall effect of well-watered vegetation, mainly trees, would be to reduce air temperature on a hot dry day by about 3.5° centigrade (7° Fahrenheit). Differences in temperature between a surface exposed to the sun and one protected under a canopy of trees may greatly exceed this.

The effect of a few trees may be fairly significant. However, doubling the area covered by the trees will not double the effect on the climate. Thus the planting of a single tree in an urban area can be fairly significant; such a tree will remove prodigious amounts of heat from the air and will use it to evaporate water.

Putting in another tree near the first one may double the area covered by vegetation, but probably would not double the amount of heat removed because the second tree is influenced by the first. So the effect of trees on air temperature will be most significant when they are planted in areas where there are no existing trees.

USDA Forest Service researchers have noted that transpiration from a single city tree may produce 600,000 B.t.u.'s. per day for cooling. This is equivalent to five average-size room air conditioners running approximately 20 hours per day.

However, remember that plants transpire at a high rate only when they are well supplied with water. Most city trees, at least in the Northeast, do not appear to suffer from a shortage of water. I suspect that many trees in urban areas are able to tap underground sources of water such as sewers and storm drains. Also, many urban dwellers are compulsive plant waterers, and they provide the trees with enough water to allow a fair rate of transpiration.

There is another way that trees affect the climate. Trees and tall shrubs provide a mechanical obstruction to wind movement by blocking or deflecting air currents. This affects the force, direction, and speed of the wind. Naturally, the degree to which trees and shrubs influence the wind will vary with height, length, and width of crown as well as the densities of individual crowns and groups of plants.

When an air current reaches a group of trees or other tall plants, part is deflected upward with only a small change in speed. Another part passes under the crowns, but at a rapidly decreasing speed. When wind strikes an extensive forest, there is a marked reduction in wind speed close to the forest margin and only slight additional reductions within the forest.

Groups of trees planted as windbreaks are common in the Plains States. These windbreaks were designed primarily to keep bare soil from blowing away. Of increasing interest in urban areas is the potential use of trees and shrubs along busy highways to reduce sudden gusts of wind.

As an example, a double row of maple trees with a height of about 40 feet, and oriented perpendicular to the prevailing wind direction, will reduce wind speed by about 50 percent in the area immediately downwind. As might be expected, the effect of a row of plants on wind speed is greatest when the row is perpendicular to the prevailing winds. The effect decreases markedly as the wind angle to the vegetation decreases from 90 degrees.

Single large trees will provide an impermeable barrier against wind over a very short distance, but probably will not affect wind speed significantly. However, in urban areas, rows of trees and shrubs along busy highways have considerable potential. They will reduce the sudden wind gust and the high air temperatures over the pavement as well as diminish the amount of dust and debris transferred from the highways to adjacent living areas.

The effect of plants on precipitation has been somewhat overrated. I think this is because trees or shrubs have offered most of us some protection in

Trees between north and south lanes on this freeway in New York State reduce wind and dust activity, and lower the noise levels, as well as creating a scenic drive.

a downpour at one time or another. At the onset of a storm, leaves and branches intercept the rain and keep it from falling to the ground.

The tree crown canopy has a total leaf surface that is often five to seven times the canopy area as we view it from the ground, so it has a great deal more surface on which to hold rain water than the ground area it covers. After the surfaces of the leaves are covered, though, the canopy can hold additional rain only as water is evaporated from the plant surfaces. In general, high vegetation intercepts approximately 15 to 20 percent of the rainfall.

Another important and often overlooked aspect of plants in relation to climate is the effect they have on snow. Trees retain more snow than rain on the surfaces of their branches and needles and hold snow longer, particularly when the weather is extremely cold and the wind is light. Trees are planted in watershed areas to shade the snow on the ground and thus retard melting of the snow and subsequent runoff. This technique is important to the city dweller because it assures a constant water supply and reduces the likelihood of floods.

If properly used, trees and shrubs can reduce the drifting of snow around dwellings or on highways. I believe the use of plants to affect snow deposition

Trees and shrubs provide a cool retreat in urban areas.

may also be of considerable importance in ski areas where the proper location of trees may provide a channeling of snow to desired areas on a ski slope.

In conclusion, the effects of plants on climate will seldom be dramatic. However, plants can have a very positive effect in modifying the microclimate of an area. The esthetic aspects must also be considered in assessing the effects of plants on man. The cool, peaceful setting of a small group of trees in an urban area provides benefits in climate control and mental well-being.

The type of trees or shrubs used can have an effect on the modification of climate. Large conifer trees will tend to make the area cooler in both winter and summer; deciduous or leaf trees will tend to reduce temperature only in the summer.

For most of the temperate areas, a mixture of both needle trees and leaf trees or shrubs will probably be most beneficial. The evergreens such as arborvitae, and spruce types used in conjunction with the maples or oaks, should provide a workable combination.

gardening to help solve your erosion problems

PLANTS AND TECHNIQUES developed to conserve soil and water on farms and ranches are fast finding their way into our cities and suburbs.

Add these to the more sophisticated urbanized plant species and methods already available or in use around town. You will find you have an imposing list from which to choose solutions to the erosion control problems that may be plaguing you.

You may be having trouble every time it rains with that high steep bank behind your house which cascades mud into your window wells or onto an irate neighbor's lawn. Or, possibly you have deep gullies forming in low bare soil areas where excess storm waters rush off your property.

Have the children worn big bare areas in that pretty bluegrass lawn with all their romping? Perhaps you get a swirling cloud of dust and dirt every time the wind blows. And, do the rocks seem to grow faster than the plants in your rock garden because the soil is washing away? All of these are erosion problems faced by Mr. Average Homeowner, and most can be solved with the right plants.

Selection of proper plants, choosing the best ways to get them established, and then deciding on treatment measures for long-term management of the protective vegetation are all important steps in developing and maintaining erosion-resistant vegetative cover.

In selecting the plant for your job, be sure it is well adapted for the purpose and to your area. The plant should be able to grow well in the type of soil you have, and need only modest additions of lime and fertilizer. It must thrive under your climate and rainfall. It should have the vegetative characteristics to carry moving water, protect slopes from raindrop impact, provide attractive long-lived cover, and be reasonably easy to establish and maintain.

You may even want plants to serve as windbreaks to prevent soil blowing, or to drift snow where the accumulated moisture will be beneficial.

Fortunately, plants often have multiple uses. So it is possible to pick a variety that will provide good erosion control, food and cover for wildlife,

---

Author WILMER W. STEINER is Chief Plant Materials Specialist, Plant Sciences Division, Soil Conservation Service.