Landscaping for Energy Conservation
Landscaping can save energy by protecting homes from sun and wind. Homes on rural sites are especially vulnerable to climate extremes, but homeowners in towns and cities can also benefit from windbreaks, fences, and trees.

**NATURAL FORCES AND COMFORT**

Our early ancestors sought warmth in the sun, protection in caves, and cooling breezes during humid spells. By carefully selecting building sites and building materials, they could take advantage of positive climatic forces. In so doing, they were able to increase their physical comfort and reduce the time and effort required to find and store energy. Today, people still strive to keep warm when it’s cold and cool when it’s hot.

When energy was inexpensive and abundant, the natural forces that affected our comfort could be modified by mechanical heating and cooling systems. Solar radiation, temperature, wind, and humidity—natural forces that change with local conditions—were ignored. The homeowner was protected by the building shell.

Because of increasing energy costs, homeowners and builders today are interested in making housing more energy efficient. Modifications in the building shell can help. However, landscape planning and design can also modify the "microclimate" around the building. Landscaping can reduce the building’s reliance on a mechanical energy system, without sacrificing comfort for its occupants.

What temperatures and humidity make people comfortable? Researchers who have studied this question found that there is a "human comfort zone." This comfort zone is a range of temperature and humidity that is most comfortable for human activity. In the comfort zone, air temperature is 70 to 80 degrees and humidity 40 to 50 percent. People can perform normal activities efficiently. In many houses, the furnace or air-conditioner is the only way to keep the building within the comfort zone. There

Deciduous trees shade the house in summer. Evergreens act as a windbreak in winter.
are other means, however, of keeping a building warm or cooling it down.

SOLAR HEATING FOR WARMTH
One way we can warm our bodies or buildings is by trapping the sun's radiant energy. Radiant energy (or short wavelength radiation) travels across the vacuum of space. Objects in the path of the sun's rays absorb radiant energy.

Streaming in through windows, sunlight heats the objects inside the house, as well as the building shell.

Heating continues until the sun no longer strikes the window. Without this heat source, the room begins to cool. The people and objects that had been warmed now give up their heat to the room in the form of long wave radiation. Long wave radiation cannot pass through window glass. The only way the trapped heat can escape is by means of conduction—heat lost by direct contact with a cold surface. When window draperies are closed, conduction heat loss is reduced. In this way, heat gained from the sun can be maintained for a longer period.

When you're building a house or developing a landscape plan, make sure you don't prevent the winter sun's rays from entering south-facing windows. In the summer when it's hot, you'll naturally want to provide as much shade as possible. But since the sun's angle is lower in the winter, if you plan correctly, you can enjoy the sun in winter, but not be overheated in summer. (See our publication, Circular C3.2 Solar Orientation, for more on how to position your home on the lot.)

You don't even have to live in the South to benefit from winter solar radiation. In northern latitudes, even during winter, the sun warms the south side of a building. Solar radiation will be even greater if snow reflects the sun's rays.

Control Sunlight With Trees
The use of evergreen trees or tall growing shrubs must be restricted to locations other than the southern exposure. Any large plant material planned for the south side should be deciduous. Deciduous trees and plants lose their leaves in winter. These allow most of the sunlight to reach the wall surface.

Deciduous plants can, however, reduce the amount of solar radiation received. Because of the trunk, branches, and twigs, less sunlight passes through deciduous plants. The larger or more massive the trunk, branches, and twigs, the less sunlight reaches the building. The reduction of solar radiation can be as little as 25% from trees with an open
character, and up to 60% for trees with dense foliage.

Solar geometry is critical for shading. Seasonal changes in sunrise and sunset will also influence plantings and shading. In the winter the sun rises and sets well to the south of East and West. This corridor for solar access should not be obstructed. In summer, however, the sun rises and sets to the north of the east/west line. The sun’s position in summer not only radiates the south wall, but the east and west walls as well. Protecting this corridor with shading can enhance summer comfort.

**SHADING**

In warm weather months, the east wall of a house is fully exposed to morning sun until 11 o’clock. The south wall and roof take direct heat from 11 to 1 o’clock. For the remainder of the day, the west wall is subjected to the sun’s heat. Though the heat is more intense during the middle of the day (because it is shining down at nearly a 90 degree angle), the duration of solar exposure is longer in morning and evening. Thus, east, west and southern exposures are handled differently in terms of shading. Use the chart on page 6 to help you plan shading. The illustrations on the next page show how the time of day and season affect how much sun strikes the house.

*The sun’s angle is high in summer and low in winter. Roof overhangs on the south-facing side of the building will shade windows in summer; trees can be used to shade east-and west-facing walls.*
During summer, trees and roof overhangs provide shade. These illustrations show how shadow patterns change during the day.

- Shadows at 6 a.m.
- Shadows at noon
- Mid-morning at 9 a.m.
- Early afternoon, about 3 p.m.
- Late morning
- Early evening
Use this chart to plan landscaping. A scaled drawing of your house can be placed on the chart. Orient your drawing by using the compass headings. The text will guide you in tree placement.

**Eastern Exposures**

Recommendations for the eastern exposure are less precise than for the south and west. On the east side of a building, the heat build-up is potentially less significant. From sunrise until 9 o'clock, there is not a significant build-up of heat because of overnight cooling (resulting from the previous day’s heat being “re-radiated” into the night time sky). Cooling is reduced by cloud cover, as clouds trap the heat near the ground. In cooler climates, this early morning sunlight may actually be welcome. But in hotter, humid climates, any morning heat, added to that which already exists, would further increase the discomfort level; therefore, shading of the east wall is recommended.

For early morning shading, place a tree at approximately the 6 o’clock a.m. position on the chart on the next page. A 30-foot tree should be placed about 15-20 feet from the house to gain the maximum area of shadow. If less distance is available, a small tree closer to the building will do. Plan tree placement to shade east windows.

By 9 o’clock, the heat build-up of the sun has reached a level to require shade, regardless of geographical location. For this late morning shading, the tree should be located at the 10:30 to 11 o’clock position. This tree should be at least 30-40 feet high and no further than 18-20 feet from the building. This placement will not only shade the southern half of the east wall: It will protect a portion of the roof and the eastern portion of the south wall. Similarly, another tree of the same height and distance from the house in the 1:30 or 2 o’clock position would afford the same type of protection to the west portion of the south wall and the southern portion of the west wall.

**Southern Exposures**

Shade trees are not effective for shading the south wall unless the trees are planted very close to the building. Summer sun hits the south wall from 11 to 1:30. This coincides with that period when the sun is at its highest altitude, which means that the length of the shadow is very shallow. The shadow will not extend very far beyond the tree crown. In this situation, the only effective shading of the south wall would be the roof overhangs, which, if wide enough, will cast shade well down the building wall.

Sun shining from the 12 o’clock position strikes the building walls at an oblique angle. The sun’s heat, however, is more readily absorbed when it shines...
The noonday sun causes less heat build-up on the south wall than does the lower altitude sun on the east or west wall. The roof area facing the South is vulnerable to major heat gains for the very reason that the sun is close to perpendicular to its surface. Where possible, large shade trees, close to the house, might provide shade to the roof. Such trees should carry their lower branches high enough to avoid damage to shingles.

Although trees do not reduce heat build-up on the south side of the house, they may still be used for aesthetic purposes. Trees on the south, however, will reduce winter solar radiation.

Western Exposures
By the time the sun reaches the western quadrant, it has gained the maximum heat build-up. Any sun reaching the west wall causes maximum heat gain. The wall absorbs the sun's heat, where it is conducted through the wall and into the west-facing rooms. The rate of conduction will depend on the building material. The time delay involved in moving the heat through the wall materials is called *thermal lag*. Thus, it is often 10 o'clock at night before the daytime heat absorbed by the outside wall is reradiated into the house. These rooms remain at a higher temperature all night. For this reason, total shading of the west wall is important.

The landscape plan provides four large shade trees and additional shading on the west wall from dense shrubbery.
If space is not available for more than one tree, locate the tree at the 5 o'clock position. A large tree, located further from the house, will cast longer shadows because of the low altitude of the sun. Along with this tree, include four or five good linear shrub plantings (or a fence) to intercept the radiation from the sun's rays passing underneath the crown of the tree. As much shading as possible on the roof area, especially in early afternoon, would also be advisable.

For west-facing wall exposures, research indicates that every 1000 sq. ft. of wall area subjected to long term solar radiation requires an additional one ton air-conditioning capacity to keep adjacent rooms within the human comfort zone. Every 55 sq. ft. of glass area radiated also requires an additional one ton of air-conditioning capacity. You can save money on air conditioning if you shade the house with trees.

**MORE ABOUT SHADING**

Vines can be used to shade wall areas. Vines grow on surfaces either by twisting over a lattice framework or by attaching themselves to the wall with tendrils. Tendrils can damage older masonry structures. Vines may be useful in shading newer masonry buildings that use portland cement mortar because the mortar is harder and less likely to be damaged by vines.

In most cases, however, allowing the vines to grow over a lattice framework offers several advantages. It provides a dead air space between the vine and the building, enhancing cooling and avoiding moisture damage to wood siding. (Vines can trap moisture and excess moisture...
A lattice frame, hinged at the bottom, allows the frame to be laid on the ground. Building maintenance and painting can be achieved without damaging the vine.

A lattice frame, hinged at the bottom, allows the frame to be laid on the ground. Building maintenance and painting can be achieved without causing serious damage to the vine itself.

Shrub planting, either evergreen or deciduous, along the building facade, will provide shade for the lower wall surface. If these plants are sufficiently dense and twiggy, they will also hold snow in winter. Trapped snow will further insulate the house against cold air infiltration. The height, arrangement, and composition of these plants should be carefully planned according to the building design and the overall landscape plan.

CONTOURS OF THE LANDSCAPE
While plants play a large part in reducing the energy demand for heating and cooling, other elements influence the microclimate around a house. The land's contours, the landscaping materials, structures (fences, tall buildings), and special features, such as water, are all important. Every change in the landscape alters the microclimate, creating temperature fluctuations that can make the difference between comfort and discomfort.

A house located on a south or southeast slope will get a lot of sun. A house on a western slope will get late afternoon sun. A house on a north slope will be on the coldest side of a hill. The ideal location will depend on whether heating or cooling is a greater problem, but generally a house located below the crest is the best location.

If you live in a low area, study the cold air drainage patterns. These patterns will be the same as surface water drainage. The downhill flow of cold air, following the path of least resistance, can be easily diverted by vertical elements—hedges, dense shrubbery, walls, or fences. If you place these landscape elements carefully, air flow can be channeled to avoid cold air build-up around the house.

Locating these barriers diagonally across a slope provides better protection than a horizontal barrier. Cold air would eventually overflow a horizontal barrier like a mighty waterfall. The barrier must be dense all the way to the ground because the coldest air is next to the ground.

A cold air mass moving down hill can be diverted by planting a windbreak.

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SURFACING MATERIALS

All the surfaces around the house are heated by the sun. Ultimately, these things become little "suns," giving out light and heat of their own. This occurs in all seasons and can be an advantage or disadvantage. The choice of surfacing material will have a significant influence on the temperature radiating toward the house.

The darker, denser materials of asphalt, sand, and earth absorb heat more readily and raise the temperature of the surface layer of air above them. Grass is generally 10 to 14 degrees cooler than the temperature of one of these materials. As the length of grass increases, the temperatures above are even cooler. This suggests that ground covers, whose foliage may be up to 12 inches high and layered with air spaces, will provide significant cooling during the summer heat.

Where concrete or asphalt walks, drives, or patios are placed near the house, the planning for shade becomes critical. Other areas around the house should be in grass or ground cover instead of bare soil or rock mulch.

One tree, through its air-conditioning process of moisture evaporation, provides the cooling equivalent of five 10,000 Btu air conditioners.

Stone or gravel will absorb heat from the sun and reradiate it toward the house. Although white stones or gravel reflect more of the sun's heat than they absorb, there remains enough heat in the stone to heat the air above it. These aggregate ground covers also add an annoying glare. Obviously, very dark-colored or black stones and gravel are especially bad. Because of their dark color, they absorb the maximum heat from the sun. By mid-day they can be exceedingly hot.

Light reflection and reradiated heat are not always negative factors. Consider the north side of a building which is often dark and gloomy because of restricted window areas and lack of sunlight. Reflected light from fences or walls, if painted white or light colors, will add to the interior light level. Since the north side of the house is also colder in winter, these same structures can be designed to reflect accumulated heat to the north walls.

TREES AND SHRUBS

The effect of surface heat can be reduced by planting trees and shrubs. A cooling process occurs when plants evaporate large amounts of water into the atmosphere. As a plant evaporates moisture from the liquid state to that of a gas, the air temperature is reduced. This is called a latent heat process. One tree, through its air conditioning process of moisture evaporation, provides the cooling equivalent to five 10,000 Btu air conditioners.

Temperatures under trees can be 15 to 25 degrees cooler; cool air, being heavier, sinks to the ground. This is especially noticeable when the tree is located next to a concrete area.

WIND

In overheated periods, the wind can help reduce energy demands and add to human comfort. However, during underheated periods, effects of wind can greatly increase our energy consumption. When the wind ventilates an area or building, it evaporates moisture, and it cools by accelerating convective and con-
ductive heat transfer. (Heat always moves from the warmer to the cooler surface. This transfer of heat, via air or water, is called convective heat transfer, while the transfer of heat between two surfaces in direct contact with one another is a conductive heat transfer.)

In summer, the prevailing wind and local breezes should be directed over the property. During the cold months, barriers should be used to reduce the impact of the wind in order to decrease infiltration of air through cracks, crevices, and pores of surfaces, and to reduce heat transfer through convection and conduction.

In summer, maximum air flow through the house is desirable. Convective and conductive cooling occurs as wind passes over the house.

In the wind shadow of a large evergreen, the house is protected from buffeting winter winds. The row of shrubbery lifts the wind up and over the house.
Windbreaks

Evergreen trees are the best natural material for slowing down the wind; however, properly designed fences can also be effective. Such barriers are commonly called windbreaks.

Windbreaks should be located upwind from the house and at right angles to the wind. In most sections of the country, this will be the west and north sides of the property. These directions might change for those locations with significant topographic changes or large structures nearby. Check the wind patterns near the house to make sure you know the wind direction for each season. Patterns of drifting snow can help you determine wind direction or you can contact your local weather service.

The layout and depth of the windbreak will depend on the space available. Large evergreen trees, planted three rows deep and staggered row to row, make an ideal windbreak. Rows should be 10 to 12 feet apart, with the distance between trees 6 feet.

On smaller properties, use narrower growing evergreens, such as arborvitae, junipers, and yews. Hemlocks could also be considered because of their tolerance to shearing. Yearly trimming would keep their height and width to the size desired.

The greatest protection from a windbreak will fall within a zone that is equal to the height of the windbreak multiplied by five. Significant protection extends to an area 10 times the height of the windbreak's trees.

In cities, the best protection from wind might be a fence. Since 6 feet is the maximum height permitted for fences, the zone of protection will be reduced. For maximum protection, fences should be close to the areas needing protection. A good windbreak fence is constructed of vertical boards that are relatively narrow, with space between to allow the air to move through but at a reduced speed.

A windbreak fence made from vertical boards with spaces between for air passage is good protection.