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UNIVERSITY OF FLORIDA

IFAS EXTENSION

Enviroscaping to Conserve Energy: a Guide to Microclimate Modification[1]

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Introduction

In northern Florida, temperatures fall below freezing on an average of 15 to 25 days every year (Black, 1993). Even in Miami, winter fronts with associated winds can cause uncomfortably cool temperatures for short periods of time. In addition, Florida's long, hot and humid summers create a high demand for air conditioning during 5 to 7 months of the year. Approximately 50 percent of the energy consumed by a home in Florida is used to maintain interior comfort. Most of the energy used to heat and cool our homes comes from the non-renewable fossil fuel energy resources, coal, petroleum and natural gas.

Florida homes use approximately 819 trillian Btu (a heat unit called British thermal unit) of energy every year. As much as 80 trillion Btu of this energy could be saved by effective management of the microclimate that surrounds our homes. Eighty trillion Btu is enough energy to power approximately 529,000 homes in Florida.

This energy savings would reduce the strain on individual pocketbooks and the state's bank account. Florida currently imports from other states approximately 98 percent of the petroleum and 100 percent of the coal burned at the power plants to make our electricity. This energy savings would reduce the strain on our environment, too, by reducing the quantities of greenhouse gases and pollutants produced when fossil fuels are burned.

A microclimate is any small, local area within which the effects of weather are both relatively uniform and easily modified. Microclimate modification involves the best use of structural and landscape design elements to maximize or limit sunlight, shade and air movement. Structural modifications involve the design of the house and associated construction (walkways, fences, patios). Landscape modifications (enviroscaping) involve the use of plants to further increase or decrease the impact of sun and wind upon the local environment.

The "passive" methods of microclimate modification discussed in this publication are simple,

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low-cost improvements that can decrease the energy costs associated with maintaining interior comfort.

Sructural Elements of Microclimate Modification

When choosing or designing a new home, several decisions strongly influence the degree to which interior comfort requires energy inputs for heating or air conditioning. The homeowner should incorporate effective insulation in ceilings and walls, and weather stripping around windows and doors, even if local ordinances do not require such practices. Total energy savings of 50 percent to 60 percent can be realized if conservation practices are followed in new home construction (Buffington, 1979).

Orientation

In Florida's hot and humid climate, a house is more energy efficient if it is oriented with the long axis running east-west (Figure 1). With this orientation, the short walls of the house receive most of the direct morning and afternoon sun, thereby reducing the total heat load on the structure. An east-west orientation can save as much as $75 to $100 per year in cooling costs alone for the average home. In the winter, when the sun is lower in the sky, the south facing long wall receives the heating benefits of solar radiation. Divergence of up to 10°F, in either direction from this orientation, is allowable to compensate for the prevailing wind direction or other specific site requirements.

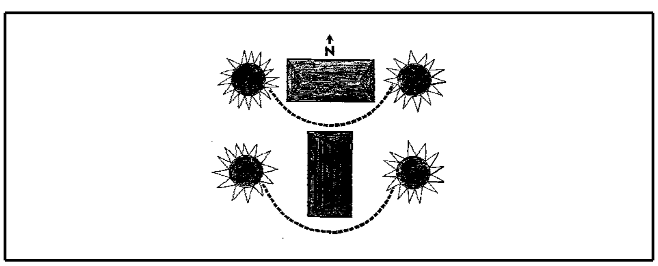

Figure 1. A house is more energy efficient if it is oriented with the long axis running east-west.

Roof and wall colors

Light-colored materials reflect sunlight; dark materials absorb the radiation. A house with dark walls and roof is less expensive to heat in winter, but more costly to cool in summer. Light-colored walls and roofs lower cooling costs but increase the need for winter heating. In Florida, the use of light-colored materials is more cost effective and energy efficient, since the cooling season is considerably longer than the heating season.

Fencing

Fencing is primarily used around homes to ensure privacy or mark boundaries. Fencing also directly influences air-circulation patterns. Air movement can affect the energy efficiency of the home, depending on the season of the year, direction of prevailing winds, and degree of dependence on air conditioning for home cooling. Air movement around the home may raise home energy consumption by increasing conductive heat loss (in winter) and heat gain (in summer) through walls and windows, and the infiltration of outside air around the edges of windows and doors.

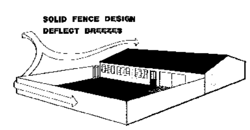

Figure 2. Solid fence design deflects breezes.

In Florida, winter's prevailing winds are from the north or northwest. Thus, a solid fence on the north side of a house can provide a barrier against cold winter winds (Figure 2). Winds from the south, southeast and southwest predominate during the summer months when effective air circulation is generally desired. Open fencing, especially with bottom clearance, maximizes air flow and reduces reliance on air conditioning for cooling (Figure 3).

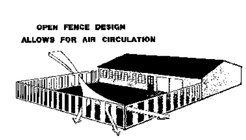

Figure 3. Open fence design allows for air circulation.

When air conditioning rather than natural cooling is used to cool the home in the hotter, summer months, prevailing winds should be blocked or diverted away from the house to reduce warm, humid air infiltration. In general, vegetation provides greater flexibility in directing air circulation and is a better choice than fencing expressly for this purpose.

Other Structural Features

In summer, large roof overhangs can help shade windows and walls, as well as walkways adjacent to the house. Arbors or trellises over outdoor living areas increase comfort and shade nearby walls. Decks should be built with bottom clearance to allow air to circulate below the structure. If possible, driveways should be located on the east or north side of the house to reduce heat buildup during warm afternoons.

Solid surfaces such as concrete and asphalt, which reflect a great deal of heat, should be kept to a minimum. Brick driveways build up less heat than either asphalt or concrete and produce less glare than concrete. Ground cover plants and organic mulches are the best option for covering large areas. Ground covers offer a cooling effect and are not energy intensive. Organic mulches reduce runoff, are inexpensive and an attractive alternative to pavements.

Landscape Elements of MIcroclimate Modification

Plants provide the most economical means of modifying microclimate around a home and represent an investment in future energy savings. Research in Florida has shown that energy costs for air conditioning at certain times of the day can be reduced more than 50 percent by proper placement of the right plant materials around a residence.

Plants in the landscape interact directly with the two primary comfort factors of Florida weather: sun and wind. Summertime heat gain in a home can be reduced by using plants to:

1. shade the residence from direct solar radiation,
2. either divert or channel air movement away from or towards the house,
3. create cooler temperatures near the home by evaporation of water from their leaves (transpiration).

Heating costs in winter can be decreased by selecting and properly locating plants so that:

1. the amount of direct solar radiation received by the home is maximized and
2. the effects of cold winter winds are minimized.

In many areas of Florida, the wasteful practice of completely clearing building sites of existing vegetation is being abandoned. Existing trees should be incorporated into new-home design whenever possible. Mature stands of native vegetation can often provide the desired energy-saving shade and wind control that would otherwise require years to develop from new plantings of nursery stock. Native plants are well adapted to local climate and soils, and established natives do not ordinarily require supplemental irrigation or fertilization, making them very energy efficient. Leaving too many trees around buildings, however, contributes to mildew, mold and other moisture problems in and outside the structures.

Shade

Trees

Trees are the most valuable landscaping tools for passively increasing the interior comfort of a home. Once established, most landscape trees require little maintenance and represent an appreciating investment in the home's value. Trees provide good shade and modify air movement effectively. How a particular tree species performs these functions depends on how tall it grows, whether or not the leaves stay on the tree all year, and the shape and density of the canopy. Lists of appropriate trees and how they rate for these specific qualities are in these publications:

EES 40 "Enviroscaping To Conserve Energy: Trees for North Florida"

EES 41 "Enviroscaping to Conserve Energy: Trees for Central Florida"

EES 42 "Enviroscaping to Conserve Energy: Trees for South Florida"

These publications are available at your county extension office.

Trees that grow 60 or more feet tall are capable of casting shadows over the roof of a typical single family house. Unfortunately, new plantings of most large growing trees require 20 or more years to reach full size. The homeowner is probably better off investing in quality ceiling insulation, attic ventilation, and construction of radiant barriers (a layer of aluminum foil situated in the air space between the roof and the attic insulation) unless a preexisting tree canopy effectively shades the roof during the summer months (Fairey, 1984a & 1984b).

Large trees overhanging the roof of a house do present the risk of damage from falling limbs, and the nuisance of clogged rain gutters full of leaf and twig litter. The planting sites of new trees must be carefully considered to optimize future shade benefits while minimizing these potential problems. If a solar water heating or electric system is on the roof, careful attention must be paid to the positioning of shade trees so that the efficiency of the system is not reduced.

Eastern and western wall exposures accumulate the most heat during the long days of summer. Tree shading should thus be maximized on these sides of the house. South walls also benefit from tree shade. Southern exposures relatively free of direct radiation in June can permit significant heat-load increases by August as the earth's position relative to the sun changes (Parker, 1978; 1983a; & 1983b).

Windows are the most direct route for sunlight to enter the home. Trees (or shading devices such as awnings), therefore, should be positioned to shade them throughout the day.

Trees can provide valuable shading of sidewalls, particularly in older homes where walls have little insulation and retrofitting is prohibitively expensive. Small (up to 25 ft.) or medium-sized (25-40 ft.) trees perform this function well and won't grow out of bounds. Fast-growing trees can be planted at the same time as slower-growing species to provide a temporary solution to shading problems. Such trees can be removed later as the slower-growing trees approach their mature heights. Care must be taken that these vigorous, temporary trees do not shade or otherwise compete with the slower-growing, more permanent landscape elements.

The outdoor compressor/condenser unit of the air conditioning system uses less energy when it and the surrounding area are shaded from direct sun during the entire day. A tree can shade the unit when the sun is overhead, while nearby shrubs can provide protection during the early morning and late afternoon hours. However, care must be taken not to block the conditioner's air flow ("short circuiting"). If the warm discharge air is prevented from escaping, the intake air temperature rises, causing the unit to operate less efficiently.

In winter, the sun is low in the southern sky. Southern exposures of a home in north and central Florida can receive free benefits of passive solar heating, provided that deciduous trees are used along the southern exposures (Figure 4). Deciduous trees shed their leaves in the fall, and are bare during the coldest months of the year.

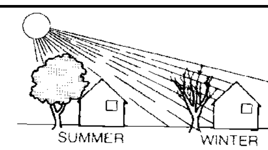

Figure 4. Summer shading and winter sun-warming deciduous trees.

In south Florida, where winters are short and mild, evergreen trees along the southern exposures are best because heat buildup prevention to lower air-conditioning costs during the long summer is most important.

Evergreen trees maintain their leaves throughout the year. There are two types: broad-leaf (e.g., Southern magnolia, *Magnolia grandiflora*; American holly, *Ilex opaca*), and needle-leaf (e.g., pines, *Pinus spp.*; cedars and junipers, *Juniperus spp.*). Broad-leafed evergreens provide dense shade year round, and are most useful as shade trees in the southern third of Florida.

By contrast, the shade cast by needle-leafed trees is sparse and more open, though pruning can, in some cases, stimulate the development of a denser canopy. When air circulation (see next section) must be balanced with a certain degree of shading, more open-canopied trees may be preferred. Tree shape also influences the amount of shade cast (Figure 5).

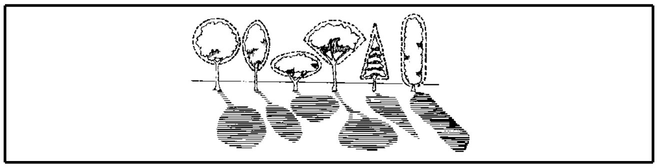

Figure 5. The shape of a tree canopy strongly influences the shade pattern that is cast.

Trees planted close to the home begin to provide shade sooner than those planted at greater distances. The benefits of new shade trees should be obtained within 5 years. To accomplish this goal, a distance of 7 to 20 feet from tree to sidewall is recommended. Lot size and the predicted mature height of the tree directly influence this distance. Trees planted closer also shade for a longer period of time during the day, and over a greater part of the hot season. The shadow of a tree planted 10 feet from the home moves across the target surface four times slower than a tree planted 20 feet away (Parker, 1978; 1983a; & 1983b).

The correct placement of trees chosen to shade the home involves consideration of the angle of the sun's rays, the mature height and width of the tree canopy, and the height of the structure to be shaded. Precise guidelines on determining shade patterns are in the following publications:

EES 49 "Enviroscaping to Conserve Energy: Shade Patterns in North Florida"

EES 50 "Enviroscaping to Conserve Energy: Shade Patterns in Central Florida"

EES 48 "Enviroscaping to Conserve Energy: Shade Patterns in South Florida"

These publications are available at your county extension office.

Shrubs and vines

Shrubs can effectively block early-morning and late-afternoon sunlight on eastern and western exposures, respectively. Small-leafed, open-branched shrubs provide shade without unduly restricting air movement for passive cooling in the spring and fall. Vegetation close to the residence also lowers the air temperature near the home, reducing the heat conducted through the walls. Espaliered shrubs, (shrubs trained to grow horizontally against a wall), can block a great deal of sunlight before it strikes and heats up the wall (Figure 6).

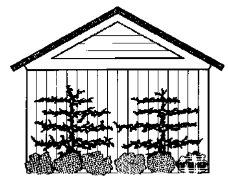

Figure 6. Espaliered shrubs can insulate a wall from heat build-up.

Vines are especially useful for shading homes when small lot size restricts the use of shade trees. Vines are either self-supporting or twining. Self-supporting vines cling to a surface by either padlike "holdfasts" (e.g., Virginia creeper: *Parthenocissus quinquefolia*) or aerial roots (e.g., trumpet vine: *Campsis radicans*). Self-supporting vines are not recommended for wood structures because they may trap moisture which can lead to decay of the wood. On brick or concrete block homes, a fast-growing, self-supporting vine can effectively prevent the sun from heating a wall (Figure 7) (Parker, 1981).

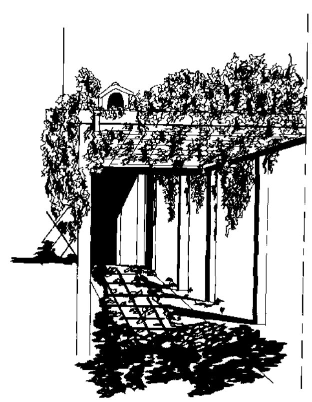

Figure 7. Twining vines block the sun from nearby windows and walls.

Twining vines (Confederate jasmine: *Trachelospermum jasminoides*; painted trumpet: *Clystostoma callistegioides*) climb by means of stems or tendrils that require some form of support. By providing a lattice-type support or a trellis, twining vines can be used to shade walls, windows, and outdoor living spaces.

As with shade trees, only deciduous vines are recommended for southern exposures in north and central Florida, to allow winter sun to passively heat the home.

Wind Control

Winter

In Florida, winds prevail from the north in winter. These northerly winds often sweep cold, arctic air into the state, the effects of which are felt most strongly in the panhandle and north central counties.

A home loses a greater amount of heat on a cold, windy day than on an equally cold but still day. About 1/3 of the heat lost is transferred through the ceilings and walls (conduction). Wind increases heat loss from the outside surfaces of those same walls and from the roof by sweeping the warm air away (convection). Cold-air infiltration through spaces around windows and doors also increases reliance on costly home-heating systems powered by fossil fuels. Windbreaks and foundation plantings can substantially reduce the heat-robbing action of winter winds.

Windbreaks

In Florida, windbreaks situated on the north, northwest and, to a lesser extent, northeast exposures of the home can provide significant energy savings during the winter heating season. The height and foliage density of trees used in windbreaks directly influence their effectiveness as wind barriers. Evergreen trees with dense canopies provide the most complete protection. However, extremely dense or solid windbreaks tend to concentrate their effects over a much shorter distance than those of moderate texture. A multilayered canopy of shrubs and trees of moderate density planted in 2 to 5 rows is the most effective windbreak design, but even a single row of trees provides some windbreak action (Figure 8). Windbreaks significantly reduce wind velocity for a distance equal to 10 times the height of the trees, less significantly to 20 times the height. The greatest amount of protection occurs within a distance of 5 times the height of the windbreak.

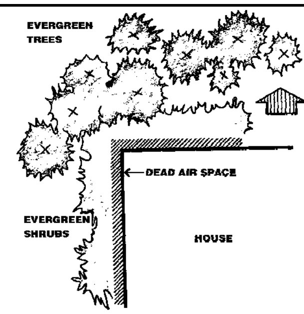

Figure 8. Windbreaks and foundation plantings will weaken the effects of cold winter winds.

Foundation shrubs

A dense planting of shrubs close to the north and northeastern walls of the home creates a "dead-air" space that has insulating properties (Figure 8). By reducing air movement in the immediate vicinity of the walls, this dead-air space also decreases secondary heat loss by cold air infiltration through cracks and window spaces. Dense evergreen shrubs (e.g., *Podocarpus nagi*, *Pittosporum tobira*) closely spaced together provide this type of protection effectively. These same shrubs keep north sidewalls cool in the summer via transpiration and shading during early morning and late afternoon.

Summer

In Florida, summer breezes prevail from the south and southeast. In north Florida, breezes during the "dog days" of July and August originate from the south or southwest; in south Florida they largely remain southeasterly (Black, 1993). How best to use plants to interact with summer air movement is largely determined by the means with which the home is cooled.

Homes Cooled by Natural Ventilation

For a home in which air conditioning is used only minimally, trees and shrubs should be strategically situated to channel cooling breezes toward the windows (Figure 9).

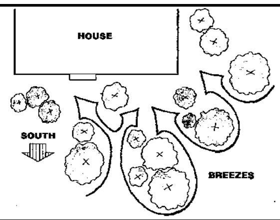

Figure 9. For passively cooled homes, trees and shrubs should be positioned to direct breezes toward windows.

Low-branching trees should be avoided on the southeastern and/or southwestern exposures or low branches should be removed (Figure 10). Plants used to shade windows from the sun should be far enough away not to restrict air movement. Shrubs near the windows can be positioned to further funnel moving air into the house (Figure 9). If shrubs are to provide low shade for exposures facing prevailing summer winds, use species that have small leaves and an open branching pattern (e.g., glossy abelia: *Abelia X grandiflora* in northern Florida; thryallis: *Galphimia glauca* in south and central Florida). Winter wind barriers on the north and northwest sides of the home also deflect cooling breezes from the south back toward the house in the summer (Figure 8).

Figure 10. To allow air movement, low-branching trees should be avoided for passively cooled homes.

Homes Cooled by Air Conditioning

During the 5 to 7 months of Florida's uncomfortably warm temperatures, some residents find it impossible to stay cool without air conditioning, regardless of the energy investment. Wind movement around the home during the cooling season substantially raises the energy costs for air conditioning by increasing the infiltration of hot, humid outside air around windows, doors and through other cracks in the building. Studies of air-conditioned homes in Florida have determined that heat gain by infiltration is actually greater than gain by conduction and radiation through walls and windows (Steen, Shroder & Stuart, 1976).

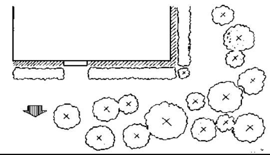

Figure 11. For air-conditioned homes, trees and shrubs should be positioned to direct breezes away from homes.

Shrubs and trees should be positioned around the air-conditioned home to divert the prevailing southern breezes away from the house, the exact opposite of what would be desired for a passively cooled home (Figure 11). A multilayered summer windbreak should be designed along the southern exposures and away from the home. The tallest components of the windbreak should be the closest to the house. In this way, a "wind ramp" can be created that will channel the breezes over the home. Along and close to the walls that face the direction of summer winds, a foundation planting of shrubs should be used to create a dead-air space that reduces or eliminates warm air infiltration. Deciduous shrubs, or open-branched species should be used on the south side to allow the sun to passively heat those exposures in winter in north and central Florida.

During the mild transitional months of fall and early spring, natural ventilation is desirable, even in homes that are air conditioned during the peak of the hot season. The south-facing foundation shrubs can be pruned in September to permit air movement, and then allowed to fill out again the following spring, if such pruning does not disrupt the aesthetic integrity of the landscape. Shade trees positioned between windows and prevailing summer winds should be low branching to provide maximum protection against air movement. Additional tall shrubs can be placed nearby but on the windward side of east and west windows (Figure 12).

Cooling Effects of Transpiration

Plants release water through pores in their leaves. The evaporative loss of this water is called transpiration. As hot air passes over the surface of the leaves, the moisture absorbs some of the heat and

Figure 12. For air-conditioned homes, low-branching trees placed by windows provide potection against air movement.

evaporates. The air surrounding the leaf surface is thus cooled by the process. This interaction is called evaporative cooling, which can lower air temperatures surrounding vegetation by as much as 9°F (5°C).

The greater the leaf area in the landscape, the greater the cooling effects of transpiration. The use of plants for shade and wind control instead of structural features such as fences and arbors thus provides an additional benefit toward maintaining thermal comfort during Florida's long summer. Air temperatures near shade trees and foundation shrubs are considerably lower than open areas, resulting in lower heat gains through nearby walls or windows. If summer breezes are channeled through and across vegetation, their cooling capacity in non-humid weather is increased.

To maximize the effects of evaporative cooling, increase the amount of plant cover around the home. Use turf grasses and ground covers to their fullest potential in the landscape as alternatives to paved surfaces such as asphalt or concrete. Many ground covers require less maintenance than turf grasses. Because fertilizers, water, pesticides and mowing are energy intensive, ground covers are energy-saving alternatives to large lawns. Suggested plant materials and guidelines for using ground covers are in the following publications:

EES 37 "Enviroscaping to Conserve Energy: Ground Covers for North Florida"

EES 38 "Enviroscaping to Conserve Energy: Ground Covers for Central Florida"

EES 39 "Enviroscaping to Conserve Energy: Ground Covers for South Florida"

These publications are available from your county extension office.

Summary

In order to reduce energy needs for summer cooling:

1. Maximize the use of ground covers and turf grasses; limit the amount of dark, paved areas.

2. Maximize shading on the roof by the overhead canopy of trees (making sure that solar panels are not shaded).

3. Maximize shading in the summer on east, west and south walls with shade trees. Shadows on the south, southeast, and southwest exposures are shorter than shadows cast on west and east exposures. Position trees and shrubs accordingly.

4. Use trellises in combination with ornamental vines for eastern, western and southern exposures.

5. If air conditioning is used only minimally, maximize the beneficial effects of prevailing cooling winds.

- Select and prune trees to allow air flow to the house.
- Avoid dense plantings away from the house that would act as a windbreak to cooling breezes
- Avoid the use of solid foundation plantings that create a dead-air space on the south side.

6. If you rely on air conditioning:

- Shade the outside compressor unit from direct sun.
- Select trees to block wind-driven air flow into the house through breaks in outside walls, such as windows, doors, and other openings.
- Situate a windbreak at some distance from the house to divert or block prevailing winds from the home.
- Reduce warm-air infiltration with a solid foundation planting that creates a dead-air

space near the house in the face of prevailing winds.

7. To minimize energy needs for winter heating:

- Use deciduous trees, shrubs and vines on south, southeast and southwest locations, except in south Florida.

- Maximize the use of evergreen plant materials in foundation plantings to create an insulating dead-air space along the northern exposures of the house.

- Create a windbreak for the north and northwestern exposures of the home using evergreen trees and shrubs in a multi-layered canopy, preferably in 2- to 5-foot rows.

With careful attention to these guidelines, the Florida homeowner can improve the value of his or her home with landscaping and realize substantial savings in energy and for the environment throughout the year.

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