DECIDUOUS TREES MODIFY TEMPERATURE OF BUILDINGS

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

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

Fuel Consumption

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

Trees and Cooler Temperatures

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

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

Tree Placement

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

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

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

Foliation Season

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

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

between the extreme dates and are not listed in this report.

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

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

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

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

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Table I

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

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

*When first true leaf is visible.

Table II

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

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

*When first true leaf is visible.

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

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

*Expected Mature Height in 30 to 40 years.

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

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

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

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

Deciduous Trees *from page 25*

Table III

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

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

*Time of complete defoliation.

Table IV

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

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

*Time of complete defoliation

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

Summary

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