

Climate Change and Plant Phenology in the Southeastern United States

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Abstract: Seasonal variations in temperature and precipitation driven by weather and climate influence life cycle changes in plants. Phenology is the study of the response of living organisms to seasonal and climatic changes to their environment. Variability in phenological events, such as the beginning of the growing season, can have important environmental and socio-economic implications for health, recreation, agriculture, the management of natural resources, ecological succession, and natural hazards.

Records of phenological events (for example, first leaf date, first flower date) could reveal clues about climate change that can be used as important indicators for predicting future climate change. A new regional phenology network, the Southeast Regional Phenology Network (SERPN) has been established to integrate plant and animal phenological event observations in the southeast with national data sets and remotely-sensed weather and vegetation data.

The first phase of the SERPN focuses on plant phenology with observations of sentinel plants and naturally occurring plants in preserved or protected areas. A dogwood anthracnose resistant cultivar of flowering dogwood (*Cornus florida* 'Appalachian Spring'), developed by the Tennessee Agricultural Experiment Station will be available in the spring of 2010 for use as sentinel plants for observations in the eastern United States. Although no single plant species represents the entire contiguous United States, a regional native plant list is being developed to address climate change issues important to southeastern ecosystems. A portion of the plants selected for the regional network will be to assimilate regionally unique plants into the broader nationwide network. In the Southeast, several plants selected for the regional network have overlapping range with the national network (for example, *Acer rubrum*, *Cercis canadensis*, *Cornus florida*, etc.). This presentation describes the plans of the Southeast Regional Phenology Network.

Definitions:

Phenology: The study of periodic plant and animal life cycle stages and how these are influenced by seasonal and interannual variations in climate. Non-biological systems also exhibit annual or period stages coupled with changes in environmental conditions (e.g., ice-in and ice-out of lakes and rivers); although this is sometimes referred to as phenology, we prefer to reserve the term phenology for biological events, and the term seasonality for non-biological events.

Phenological event: A precisely defined point in the annual life cycle of a plant or animal, generally marking the start or end point of a phenophase. The occurrence of a phenological event can be pinpointed to a single date and time (in theory, if not in practice).

Phenophase: An observable stage or phase in the annual life cycle of a plant or animal that can be defined by a start and end point. Phenophases generally have a duration of a few days or weeks. Examples include the period over which newly emerging leaves are visible, or the period over which open flowers are present on a plant.

- **Calibration plant species:** The calibration plant species component of the USA-NPN Plant Phenology Program consists of a set of 20 plants selected to help "calibrate" phenological measurements across the USA. These native and introduced plants have broad distributions and are ecologically or economically important. The USA-NPN integrates observations on calibration species to get "the big picture" of plant responses. USA-NPN observers are encouraged to include at least one calibration species in their monitoring projects. Widespread observation of calibration species is needed so that the collective monitoring data for these plants can be integrated with climate measurements across the nation.

Implementation of the Cloned Plants Project (Excerpt from Mark Schwartz, University of Wisconsin at Milwaukee)

Our overall goal is to supply cloned plants to at least 2500 core observations sites (this number comes from an initial estimate of a 25% participation rate from the roughly 10,000 National Weather Service Cooperative [COOP] observers, a major target constituent group of the program), with approximately even spatial coverage, across the entire continental USA. Our plan places two cloned plants at every observations site, so observations can continue, even if one fails to survive. A reinvigorated and expanded lilac "network" will constitute many of these sites. However, one of the limitations of lilac observation is that the cloned

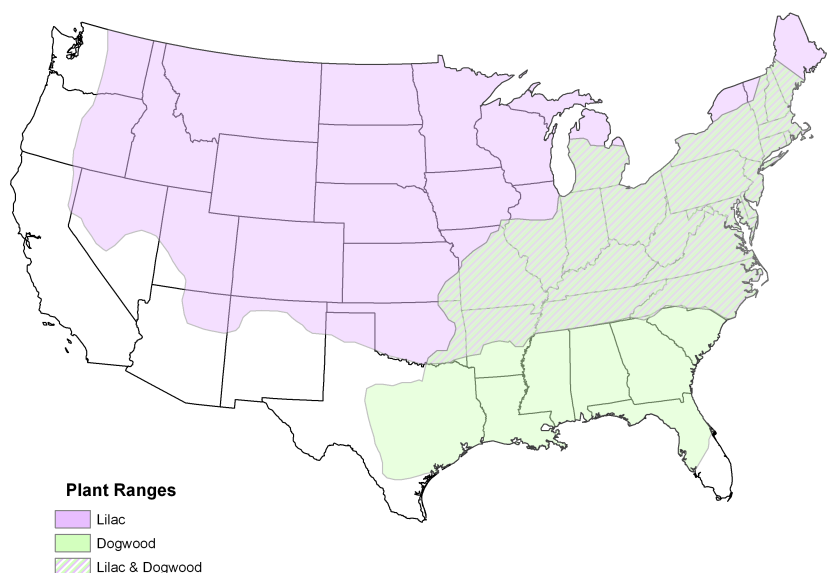


Figure 1: Idealized Ranges of Cloned Lilac and Dogwood






varietal will not grow successfully in portions of the Southeast, Southwest, and West Coast regions of the USA. Thus, the potential for clone varieties of other species to “serve” these areas needs to be investigated. Dogwood (*Cornus florida*) appears well suited for the southeastern USA, since a cloned variety resistant to the disease anthracnose is commercially available, and its idealized growth range complements and overlaps well with cloned lilac (Fig. 1). Appropriate species for the Southwest and West Coast are less certain, so more research needs to be done in order to recommend potential species for these areas.


Currently, there are approximately 430 observation sites with cloned lilacs in the continental USA. Given that full-scale efforts to recruit new observers across the entire country have not yet been employed, and many observers recruited are from other environmental observation networks (such as the National Weather Service Cooperative Program), the numbers so far are encouraging. They strongly suggest that a total future distribution of 2070 additional (2500 total) core sites nationwide is obtainable. Further, the nursery that is producing the cloned lilacs will start providing these plants direct to the public for purchase in spring 2009, which (along with partnerships with other environmental networks and education/outreach efforts) will support adding observation sites beyond the core set. Lastly, observers who monitor common lilacs and dogwood plants as part of the USA-NPN Plant Phenology Program will add to the number of stations and support the overall goals of the Cloned Plants Project, as the responses of these plants are often quite similar to their cloned “cousins”.

Plant List for Georgia – from the USA National Phenology Network (www.usanpn.org)

Indicates a calibration species

- *Acer negundo* (boxelder)
- *Acer pensylvanicum* (striped maple)
-  *Acer rubrum* (red maple)
- *Acer saccharum* (sugar maple)
- *Achillea millefolium* (common yarrow)
-  *Ambrosia artemisiifolia* (annual ragweed)
-  *Ambrosia psilostachya* (cuman ragweed)
- *Amelanchier canadensis* (Canadian serviceberry)
-  *Andropogon gerardii* (big bluestem)
- *Aquilegia canadensis* (red columbine)
- *Arisaema triphyllum* (jack in the pulpit)
- *Asclepias incarnata* (swamp milkweed)
- *Asclepias syriaca* (common milkweed)
- *Asclepias tuberosa* (butterfly milkweed)
- *Asclepias viridis* (green antelopehorn)
- *Berlandiera pumila* (soft greeneyes)
- *Betula alleghaniensis* (yellow birch)
- *Betula lenta* (sweet birch)
- *Bouteloua curtipendula* (sideoats grama)
- *Brassica rapa* (field mustard)
- *Bromus tectorum* (cheatgrass)
- *Buchloe dactyloides* (buffalograss)
- *Carya glabra* (pignut hickory)
- *Carya ovata* (shagbark hickory)
-  *Centaurea biebersteinii* (spotted knapweed)
- *Cephalanthus occidentalis* (common buttonbush)
- *Cercis canadensis* (eastern redbud)
- *Citrus spp.* (citrus)
- *Claytonia virginica* (Virginia springbeauty)
- *Clintonia borealis* (bluebead)
- *Cornus florida* (flowering dogwood)
- *Cornus florida* 'Appalachian Spring' (cloned)
- *Corylus americana* (American hazelnut)
- *Corylus cornuta* (beaked hazelnut)
- *Dodecatheon meadia* (pride of Ohio)
- *Echinacea purpurea* (eastern purple coneflower)

- *Erythronium albidum* (white fawnlily)
- *Erythronium americanum* (dogtooth violet)
- *Eschscholzia californica* (California poppy)
- *Fagus grandifolia* (American beech)
-  *Fragaria virginiana* (Virginia strawberry)
- *Fraxinus americana* (white ash)
- *Fraxinus pennsylvanica* (green ash)
- *Glycine max* (soybean)
- *Hamamelis virginiana* (American witchhazel)
- *Helianthus annuus* (common sunflower)
- *Heracleum maximum* (common cowparsnip)
- *Impatiens capensis* (jewelweed)
- *Juglans nigra* (black walnut)
-  *Juniperus virginiana* (eastern redcedar)
- *Lespedeza cuneata* (sericia lespedeza)
- *Liatris aspera* (tall blazing star)
- *Liquidambar styraciflua* (sweetgum)
- *Liriodendron tulipifera* (tuliptree)
- *Lupinus perennis* (sundial lupine)
- *Maianthemum canadense* (Canada mayflower)
-  *Malus pumila* (paradise apple)
-  *Medicago sativa* (alfalfa)
- *Melilotus officinalis* (yellow sweetclover)
- *Mertensia virginica* (Virginia bluebells)
- *Myriophyllum spicatum* (Eurasian watermilfoil)
- *Oenothera biennis* (common evening primrose)
- *Oenothera speciosa* (pinkladies)
- *Oligoneuron rigidum* (stiff goldenrod)
- *Oxalis montana* (mountain woodsorrel)
-  *Panicum virgatum* (switchgrass)
-  *Pascopyrum smithii* (western wheatgrass)
- *Passiflora incarnata* (purple passionflower)
- *Phragmites australis* (common reed)
- *Pinus palustris* (longleaf pine)
- *Pinus strobus* (eastern white pine)
- *Pinus taeda* (loblolly pine)
- *Podophyllum peltatum* (mayapple)
- *Polygonum cuspidatum* (Japanese knotweed)
- *Prunus americana* (American plum)
- *Prunus persica* (peach)
- *Prunus serotina* (black cherry)

-  *Prunus virginiana* (chokecherry)
- *Pueraria montana* (kudzu)
- *Quercus alba* (white oak)
- *Quercus rubra* (northern red oak)
- *Robinia pseudoacacia* (black locust)
- *Sambucus nigra* (black elderberry)
- *Sorbus americana* (American mountain ash)
- *Spigelia marilandica* (woodland pinkroot)
- *Symphotrichum ericoides* (white heath aster)
- *Tamarix* spp. (tamarisk)
-  *Taraxacum officinale* (common dandelion)
- *Tilia americana* (American basswood)
- *Tradescantia ohiensis* (bluejacket)
- *Trifolium repens* (white clover)
- *Trillium erectum* (red trillium)
- *Trillium grandiflorum* (white trillium)
- *Trillium undulatum* (painted trillium)
- *Triticum* spp. (wheat)
- *Tsuga canadensis* (eastern hemlock)
- *Urochloa maxima* (guineagrass)
- *Vaccinium corymbosum* (highbush blueberry)
- *Verbesina virginica* (white crownbeard)
- *Viburnum lantanoides* (hobblebush)

PHENOPHASES

Emerging leaves

In at least 3 locations on the plant, an emerging leaf is visible. A leaf is considered "emerging" once the

green tip is visible at the end of the leaf bud, but before it has fully unfolded to expose the petiole (leaf stalk) or leaf base.

***Acer rubrum* – emerging leaf**



Photo courtesy of Ellen Denny, Yale University

Unfolded leaves

In at least 3 locations on the plant, an unfolded leaf is visible. A leaf is considered "unfolded" when the petiole (leaf stalk) or leaf base is visible. The leaf may need to be bent backwards to see whether the petiole or leaf base is visible.

***Aesculus hippocastanum* - unfolded leaves**



Photo courtesy of Ellen Denny, Yale University

>=75% of full leaf size

For the whole plant, the majority of leaves are unfolded and have elongated to at least three-quarters (75%) of their mature size. Leaf size may also be estimated by viewing the canopy as a whole. At 75% of full leaf size, the canopy appears to be approximately three-quarters (75%) full.

>=50% of leaves colored

For the whole plant, at least half (50%) of the leaves (including any that have fallen to the ground) have changed to their late-season colors.

All leaves colored

For the whole plant, virtually all (95-100%) of the leaves (including any that have fallen to the ground) have changed to their late-season colors, and there is virtually no green left in the leaves.

>=50% of leaves fallen

For the whole plant, at least half (50%) of the leaves have fallen.

All leaves fallen

For the whole plant, virtually all (95-100%) of the leaves have fallen.

Open flowers

In at least 3 locations on the plant, an open fresh flower is visible. Flowers are considered "open" when the reproductive parts are visible between unfolded or open flower parts. Do not include spent (wilted) flowers that remain on the plant.

***Acer rubrum* – open flower**



Photo courtesy of Ellen Denny, Yale University

Full flowering

For the whole plant, at least half (50%) of the flowers are open and still fresh.

Acer rubrum – full flowering



Photo courtesy of Ellen Denny, Yale University

Ripe fruits

In at least 3 locations on the plant, a ripe fruit is visible.

Acer rubrum – ripe fruits



For more information about plant phenology:

www.usanpn.org (USA-National Phenology Network)

gkish@usgs.gov (for information about the Southeast Regional phenology Network)