NATIVE PLANT SOCIETY OF NORTHEASTERN OHIO

Founding Chapter Of

THE OHIO NATIVE PLANT SOCIETY

6 Louise Drive
Chagrin Falls, Ohio 44022
(216) 338-6622

On the Fringe

THE JOURNAL OF THE OHIO NATIVE PLANT SOCIETY

Volume 7 **May / June** **No. 3**

DONATE TO THE ROYAL CATCHFLY!!!

The **Campaign** to raise $5,000 to preserve the Royal Catchfly is having serious difficulties.

We need each and every one of you!!! If each member of this society would send in $10 we could make our goal.

This program is the responsibility of EVERY member of the Native Plant Society. We have made a pledge which has received attention all over the country. If we fail, we fail in front of all these poeple. I don't think that is what any of you want. The next time you have a ten dollar bill in your pocket, take it out and look very carefully at it. It will be your choice as to how you spend it: on something "here today and gone tomorrow," or on the preservation of an elegant little flower that had its place in Ohio long before the pioneers came and exterminated it from its native habitat.

Your gift to the Royal Catchfly is **tax deductible.** Your money goes to The Holden Arboretum to fund the work on Ohio's threatened plants. If we succeed in this campaign, The Center for Plant Conservation will receive a $5,000 matching grant. If you contribute, you will feel good about yourself all that day. And finally, we will give you a copy of our lovely poster depicting some of Ohio's native plants.

Are those enough reasons to **GIVE**? If not, please call me at 216/338-6622 and I will be happy to give you some more. One of our members was generous enough to give $100. We know that most of you cannot do that, but those who can, please give as **much** as you can -- $15, $25, $50.

Make checks payable to: Native Plant Society and send to 6 Louise Drive, Chagrin Falls, Ohio 44022. Sit down and do it **TODAY.**

JOURNAL IN JEOPARDY

We have received an increase in the cost of printing the Journal that will triple the expense of putting it out. The printer, who has done the Journal since the beginning, has been doing so as a contribution to the Society. Even with the increase he has presented to us, we would not be paying a realistic price.

Our alternatives are four: 1) Cut the Journal back to just a couple of pages, listing local program and news; 2) Find some way to print the Journal at less cost; 3) Cease publication altogether; and, 4) Raise dues for 1990. The current annual cost per person of the Journal is almost exactly covered by the active dues of $7.50. The new cost will rise to almost $14, or just less than Family dues of $15. Obviously, those who have joined at Sustaining and Patron in the past have been carrying the load.

Number four choice is most certainly going to happen one way or another. The philosophy of the Executive Board since our founding has been to keep the Active dues as low as possible so that no one would be prevented from belonging because of financial ability, i.e.: those who simply, for one reason or another, face difficult choices in how they can spend their income.

Your Board must make a decision soon. The Journal is subscribed to from all over Ohio and the United States and Canada. It has been highly acclaimed. Our goal was to make it even better, enlarge its scope. To cease publication or to diminish it would be a tragedy.

However, our membership has always been the **most** important factor in the NPS, and it will continue to be. To raise dues to the point that we would lose people would be even more disastrous than to lose the Journal.

What we need are **ideas and suggestions.** Does anyone know of a way to print the newsletter at reduced cost? Does anyone know of a way to get funding through a grant or a donation? Does anyone know how to cut back on the current costs of producing the Journal?

The Journal has been typed and put into camera ready format by Barbara Janes at her company,**Answering Plus.** She has always given us a minimal charge and for this she deserves the profound gratitude of the Society. I call her our **Publisher.** Working with her has been a joy. The printing has been done by Dick Evans at **Good Impressions Printing Co.** Dick has been a most generous donor since our founding. But the cost of doing business has necessarily gone up for them just as it has for everyone else.

Please write or call your suggestions to the address or telephone number on the masthead of The Journal. **We need all of your ideas.**

KENTUCKY NATIVE PLANT SOCIETY WILDFLOWER WEEKEND

In the last issue of the Journal we announced news of the Virginia Native Plant Society weekend. Each year on the first weekend in May, wildflower enthusiasts assemble at Natural Bridge State Park, one of Kentucky's premier wildflower habitats. Some of their best known botanists and ecologists will be on hand to guide field trips for identification, photography, and plant community studies. Special guest speakers, such as Bob Mohlenbrock, will give evening lectures. Programs are planned for beginners and seasoned veterans. The weekend begins on Friday, May 5, at 1:00 p.m. and goes through Sunday, May 7th. Write to Kentucky Native Plant Society, Dept. of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475.

WEST VIRGINIA WILDFLOWER PILGRIMAGE

This annual weekend will be held May 11 to 15 at Blackwater Falls State Park in Davis, W. Va. This is offered as a package deal. Members of the W. Va. Garden Club, Inc., The W. Va. Dept. of Natural Resources, and the Biology Dept. of W. Va. University will be in charge. Blackwater Falls State Park is a gorgeous area, and W. Va. is home to some rare and beautiful species of plants. For more information call 304/428-0607 or 304/348-3370.

VOLUNTEERS NEEDED

Volunteers are needed for The Native Plant Society area of the Wildflower Garden at the Garden Center. Our area is to be planted with species native to Ohio. Therefore, alien species must be removed as natives are added. Other tasks include Spring cleanup of leaves, fertilizing, rescuing plants in construction areas, soil preparation, and planting. This is a lovely place to work. If you could give just four hours each month it would be a great help, but of course, we would like people who would come every week for a few hours. You would be working in an area of sunshine, bird song, fresh air, and surrounded by flowers and nice people of like interests. What more could you ask, other than going home with a feeling of well-being and satisfaction at a job well-done at the end of the day? If interested, call Kate Harrington at 526-3122 or 721-1600.

STATE BOARD MEETING

On the 18th of March a State Board meeting was held in Columbus. Many items were discussed, but of importance to members at this time are the following. In 1990 the Annual State Field Trip weekend will be hosted by the Dayton Chapter on April 21-22 at Hueston Woods State Park. In 1991 Lisbon will host in Columbiana County at a date yet to be determined, and in 1992 Cleveland will host in Ashtabula County in early May. Remember those dates.

The Michigan Botanical Society has developed a program called "A Neat Place to Botanize." Members fill out a form and send it in to the central office where it is available to others. This plan is going to be copied by Ohio Native Plant Society. It will be useful to members traveling to other parts of Ohio and to out of state visitors. Enclosed is a blank form to use as a model. You can photocopy it and send in as many suggestions as you like.

ADAMS COUNTY NATURE RETREAT

Woodland Altars, site of the Annual Field Trip Weekend in 1988, is having a nature week from Monday, June 12 to Friday, June 16. The registration fee, if paid before May 1st, is $100 and covers all activities, four nights lodging, Monday lunch through Friday brunch, swimming and other free-time activities. Nature walks, interpretive slide shows and field trips to local nature preserves will be offered. Bird walks, live animal exhibits, swimming, and boating are available as well. Some of you may remember the rather spartan sleeping accommodations during the 1988 weekend. There are a couple of motels nearby and the Altars has some chalet rooms available at increased cost. This is a wonderful area to botanize. Call 513/588-2105 for more information.

NATIVE LANDSCAPE AWARD

The American Native Landscape Award is given to the person or organization that best exemplifies the creative uses of native plants. Points of consideration include: succession, seasonal interest, ecological fitness, regional adaptation, and artistic flavor. There are four categories and an award will be given in each category that receives suitable entries. The categories are: 1) Amateur, 2) Profession Residential, 3) Professional Land Use Planning and, 4) Professional Pure Design. The awards will be presented at the Native Plant Conference in Cullowhee, North Carolina on July 29, 1989. For exact rules and form, call 216/338-6622.

NURSERIES SELLING DUG NATIVE PLANTS

It has been brought to our attention that catalogues being received in the mail contain plants for sale that can only have been dug from the wild. Such catalogues include those from the Michigan Bulb Company that hawks the Pink Ladyslipper and Spring Hill Nursery that includes the Yellow Ladyslipper. **We urge you to avoid any business with such nurseries.** In addition, when you receive a catalogue containing such material, write to them and tell them that they are operating outside of the law and you will not do business with them, and you will tell others to avoid them. Michigan, home to lush populations of our native orchids, has been decimated by such unscrupulous activities with tens of thousands of orchids being trucked out of the state at a time. If this continues, we will lose these lovely flowers. Be an activist and help eradicate this abuse of our native plants.

PROGRAM:

April 29, Saturday, **12:30 p.m.,** Fowler Woods SNP, Wildflower Discovery Hike.

April 30, Sunday, **3:00 p.m.,** Gross Woods SNP - Wildflower identification hike.

April 30, Sunday, **1:30 p.m.,** Tinkers Creek SNP - Spring wildflower along Seven Ponds and Southpoint Trails.

May 6, Saturday, **1:30 p.m.,** Wilderness Center - Field trip to Willis Woods.

May 6, Saturday, **9:00 a.m.,** Cincinnati - Field trip to Johnson & Hazlewood Nature Preserve of University of Cincinnati.

May 6, Saturday, **10:00 a.m.** - Cleveland - Field trip to Beavercreek SNP. Meet at Gaston Mills parking lot in Beavercreek State Park.

May 6, Saturday, **9:00 a.m.** - Lisbon - All day birding and plants in Columbiana County

May 6, Saturday, **11:30 a.m.** - Howard Collier Scenic River - Wildflower hike.

May 6, Saturday, **10:00 a.m.** - Eagle Creek SNP - Identification and natural histor of over 50 species of wildflowers.

May 6, Saturday, **10:30 a.m.** - Mentor Marsh SNP - Herbal, traditional and moder uses of our native plants.

May 7, Sunday, **2:00 p.m.** - Clifton Gorge SNP - Wildflower secret hike.

May 7, Sunday, **9:00 a.m.** - Tinkers Creek SNP - Birdwalk at height of spring migratior

May 7, Sunday, **2:00 p.m.** - Kyle Woods SNP - Wildflower walk.

May 10, Wednesday, **1:00 p.m.,** Lisbon - Hike on the Gord/Vodney land.

May 12, Friday, **10:00 a.m.** - Dayton - Nature hike at Ft. Hill State Preserve.

May 13, Saturday, **9:00 a.m.** - Cleveland - Beswick Memorial Hike in Bedfor MetroPark. Meet at Egbert Road picnic area.

May 13, Saturday, **7:30 p.m.** - Athens - "The origin and ecology of bogs, fens, an marshes of Ohio" by Guy Denny.

May 13, Saturday, **9:00 a.m.** - Lisbon - Field trip to Crane Creek and Ottawa NWR.

May 13, Saturday, **1:00 p.m.** - Lake Katherine SNP - Wildflower hike.

May 13, Saturday, **11:00 a.m.** - Fowler Woods SNP - Wildflower hike.

May 13, Saturday, **8:00 a.m.** - Eagle Creek SNP - Beginners' bird walk.

May 13, Saturday, **1:30 p.m.** - Tinkers Creek SNP - A Beaver Pond study.

May 14, Sunday, **1:30 p.m.** - Wilderness Center - Spring wildflower walk.

May 14, Sunday, **2:00 p.m.** - Cincinnati - Wildflower walk in Woodland Mound Park.

May 14, Sunday, **2:00 p.m.** - Goll Woods SNP - Wildflower walk.

May 15, Monday, **7:30 p.m.** - Columbus - To be announced.

May 15, Monday, **7:30 p.m.** - Dayton - Report on the Oxbow Project.

May 17, Wednesday, **7:30 p.m.** - Eagle Creek SNP - Beaver Pond study.

May 19-21, Friday thru Monday, Wilderness Center - Field trip to Oak Openings.

May 20, Saturday, **9:00 a.m.,** Lisbon - All day plant hike in Columbiana County.

May 20, Saturday, **10:00 a.m.,** Eagle Creek SNP - Tree identification hike.

May 20, Saturday, **9:00 a.m.,** Shawnee State Forest - Division of Nature Areas & Preserves wildflower walk.

May 20, Saturday, **8:00 a.m.,** Headlands Dunes SNP - Beginners' bird walk.

May 21, Sunday, **1:00 p.m.** - Lake Katherine SNP - Canoe trip to see umbrella magnoli and Mt. Laurel.

May 21, Sunday, **9:00 p.m.** - Adams Lake Preserve SNP - Wildflower walk.

May 21, Sunday, **2:00 p.m.** - Kyle Woods SNP - A woodland premier walk.

May 21, Sunday, **2:00 p.m.** - Mentor Marsh SNP - May discovery walk.

May 23, Tuesday, **7:30 p.m.** - Lisbon - Lecture on butterflies and moths of Columbiana County.

May 27, Saturday, **11:00 a.m.** - Jackson Bog SNP - Interrelationships in the fen community.

May 27 & 28, Saturday & Sunday - Cincinnati - Field trip to Oak Opening and N.W. Ohio.

June 3, Saturday, **9:00 a.m.** - Lake Katherine SNP - Bigleaf magnolia hike.

June 3, Saturday, **1:00 p.m.** - H. Collier Scenic River Area - Woods walk.

June 3, Saturday, **10:30 a.m.** - Eagle Creek SNP - Fern walk.

June 4, Sunday, **1:30 p.m.** - Hach-Ohio SNP - Ferns and their allies hike.

June 4, Sunday, **1:30 p.m.** - Dayton - Field trip to Oxbow.

June 4, Saturday, **2:00 p.m.** - Dayton - Tour of Mrs. Marie Aull's garden.

June 9, Friday, **2:00 p.m.** - Cincinnati - "Day in Eden" tour and picnic.

June 10, Saturday, **9:00 a.m.** - Lisbon - Field trip for butterflies at Sprucevale.

June 10, Saturday, **1:30 p.m.** - Dayton - Tour of Springfield Fen.

June 10, Saturday, **1:00 p.m.** - Wilderness Center - Field trip to Holmes County for monument plant.

June 10, Saturday, **10:30 a.m.** - Fowler Woods SNP - Tree, leaf and bark identification.

June 10, Saturday, **10:30 a.m.** - Hach Otis SNP - Tree hike.

June 10, Saturday, **2:30 p.m.** - Mentor Marsh SNP - Tree hike in the marsh.

June 11, Sunday, **6:00 p.m.** - Clifton Gorge SNP - Old field ramble.

June 11, Sunday, **3:00 p.m.** - Gross Woods SNP - Recipe for a forest.

June 14, Wednesday,

June 15, Thursday, **7:30 p.m.** - Cleveland - "Aquatic plants of glacial lakes in N.E. Ohio" by Bob Bartolotta at Garfield Park Nature Center.

June 17, Saturday, **9:00 a.m.** - Cleveland - Field trip to Gott and Herrick Fens. **Limit 10.** Call 338-6622 for reservations.

June 19, Monday, **7:30 p.m.** - Dayton - "Sex Life of a Plant" by Paul Knoop at Cox Arboretum.

June 24, Saturday, **1:00 p.m.** - Wilderness Center - Field trip to Brown's Bog and Killbuck Wildlife Area.

June 27, Tuesday, **6:00 p.m.** - Lisbon - Dinner Meeting

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EVOLUTION OF PLANTS

Fossil seeds found in Kansas soil deposited 286 million years ago appear to be the oldest evidence known of an obscure but important step in the evolution of plants - the ability of a seed to remain dormant before sprouting.

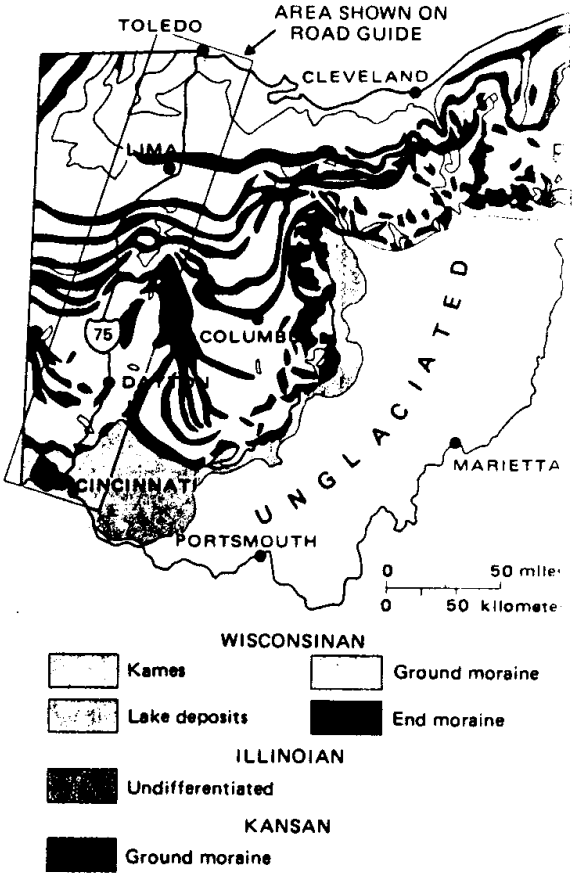
Until plants developed this ability, their seeds sprouted almost as soon as they fell from the parent. Any seeds that were blown or carried to dry soil died quickly.

We had originally intended to use an article by Dr. Jane Forsyth called "A Geologist Looks at the Natural Vegetation Map of Ohio" from the Ohio Journal of Science in 1970. One of our members felt that it was a little too technical for some of our readers and that the article printed below would be more widely understood. However, it only touches on the total subject. If you are intrigued by this article, call 338-6622 or write to the address in the masthead. If enough of you want, we will print the Journal of Science article at a later date.

LINKING GEOLOGY AND BOTANY . . .A NEW APPROACH by Jane Forsyth.

The Background

Geology is the study of the earth, including the rocks which compose it and the pattern and significance of their distribution. **Botany** is the study of plants. One might not expect these two subjects thus defined to have much in common, but nothing could be farther from the truth. Geology provides the substrate into which the plant roots extend for support, for moisture, and for nutrients. This substrate differs considerably from place to place, even in an area the size of Ohio, and a number of plants appear to be "choosey" about the nature of the substrate in which they grow. The interdisciplinary study involving both geology and botany is called **Geobotany**, or the study of the relationships of plant species and plant communities with their associated substrates. This science is still young, but already the geologic substrates of some plants are known, to the mutual advantage of both geologists and botanists as well as others interested in natural history. Some of these relationships will be presented below, though a brief introductory statement about the nature of Ohio's geologic setting seems desirable first.



GLACIAL DEPOSITS OF OHIO

The geology of Ohio, if not regarded too closely, may be divided neatly into two parts. The western part is underlain by limestone (including broad areas of its magnesium-containing variety, dolomite), a rock type that is relatively nonresistant in this humid climate. As a result, through the millions of years that have elapsed since erosion of these rocks first began (about 200 million years ago), that part of Ohio has been worn down to a comparatively flat landscape. In contrast, eastern Ohio is underlain predominantly by sandstone, a relatively resistant rock, which is underlain by shale to the west (and throughout the Cleveland area). Erosion of the sandstone is accomplished mainly by solution of the natural cement holding the grains together

by water seeping down through the rock. Although water seeps through sandstone very readily, the process of dissolving this cement goes on very slowly, giving the rock its resistant character (as one professor has said: "It is difficult to erode a sieve"). Shale is much less resistant, being worn down to low plains everywhere except where it is capped (and therefore protected) by the sandstone. As a result, erosion in eastern Ohio has succeeded only in carving out deep valleys, but not in wearing away the intervening higher land, forming a landscape of steep-sided sandstone hills or, in the Cleveland region, sandstonecapped hills.

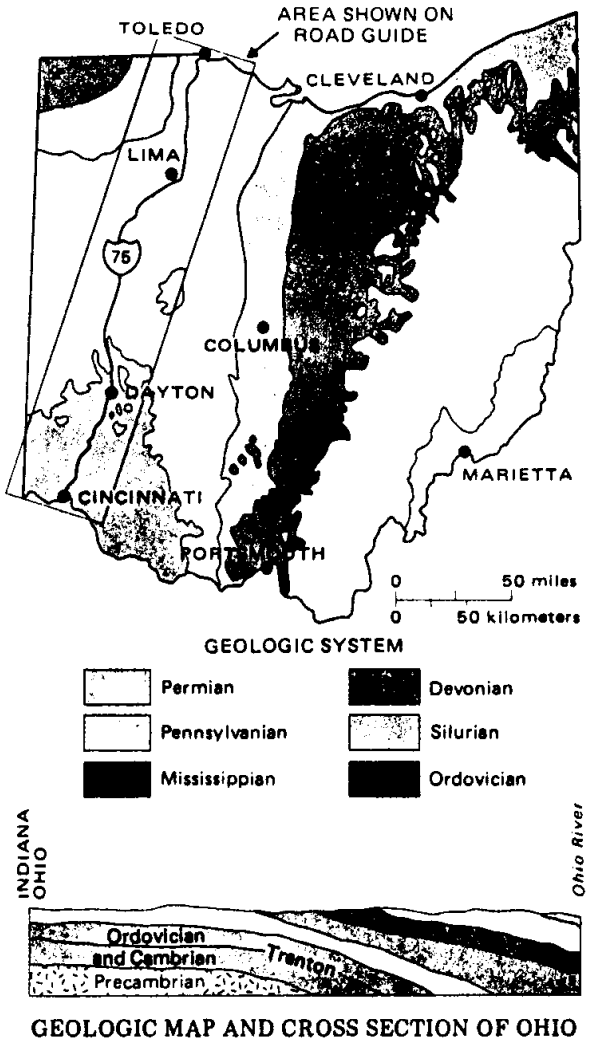
The reason for the contrast in kinds of rocks present in eastern and western Ohio is not difficult to understand. The original horizontal sequence of sedimentary rock strata in Ohio, a thick series of limestone layers overlain by shales which were in turn overlain by sandstones, was gently tilted into the form of a low arch before erosion began (see map). This arch was in part a product of those pressures which, approximately 200 million years ago (at the end of the Paleozoic Era), created the original Appalachian Mountains to the east. Subsequent erosion has cut deepest where the arch stood highest, exposing the oldest rocks along its crest which extends generally north-south through western Ohio. These oldest rocks were the limestones which are found throughout western Ohio and whose nonresistance has resulted in the erosion of that part of the state down to a nearly flat plain. Farther east, away from the crest of the arch, the youngest rock layers, the resistant sandstones, were not removed, erosion having cut deeply into the rock strata but not having eroded it completely away, resulting in the sandstone hills characteristic of this area. Typical of the Cleveland region, where the sandstone is underlain by shale, are the flat-topped uplands held up by sandstone, alternating with deep steep-sided valleys cut into the underlying shale. Most of this erosion of all the limestone in western Ohio and of the shale and sandstone in the east was accomplished by a famous preglacial stream, the Teays (pronounced "Taze") River. This river, together with its tributaries and contemporaries whose routes across Ohio are shown on a map in Bulletin 44 of The Ohio Geological Survey, was present in Ohio for a very long time--about 200 million years. As far as we know these streams continued to erode the land throughout the entire length of that long interval of time; their activities were curtailed only by the advance of the glaciers of the Ice Age (Pleistocene Epoch) less than a million years ago.

When these Pleistocene glaciers invaded Ohio only a few hundred thousand years ago or less (only 20,000 years ago for the last, or Wisconsin, advance), they were greatly slowed down by the steep-sided sandstone hills of eastern Ohio, so the glacial boundary there is no farther south than the latitude of Canton. In contrast, on the broad limestone plains of western Ohio, where there was nothing to hinder the advance of the ice. It extended as far south as northern Kentucky.

Deposition by the glacier was of two kinds: an unsorted mixture of sand, silt, clay, and boulders called **till**, accumulated directly by the melting of the ice, and the sand and gravel materials deposited by the glacial meltwater. Till occurs as a broad, continuous blanket over almost all of glaciated Ohio, whereas the sand and gravel deposits are local features occurring only within a single river valley or composing a single hill. The composition of till reflects, in large part, the nature

of the geologic materials (bedrock or earlier glacial deposits) over which the glacier moved that left the deposit. Thus in western Ohio the glacial till is rich in lime and clay, products of the glacial abrasion of the limestone bedrock. In eastern Ohio, on the other hand, most of the till contains very little lime and clay, although near the margins of the area of sandstone hills, where the ice moved from limestone bedrock onto sandstone, the till is higher in both lime and clay than it is elsewhere in eastern Ohio. Glacial sand and gravel deposits representing mostly materials washed out beyond the glacial margin (outwash) also reflect the local bedrock in part, though limestone pebbles are found in diminishing numbers with increasing distance from the source area of limestone bedrock. Hills of gravel are also present locally, occurring in considerable numbers in some places such as the Massillon-Akron-Kent region.

Based on this rather cursory summary of Ohio's general geology, some basic substrates for plants become obvious. On the plains of western Ohio the most common substrate is limy, clayey till which provides a relatively impermeable soil, high in lime but poorly drained and inadequately aerated. On this soil, water does not soak in very fast but tends to remain on the surface, creating low oxygen availability during wet periods and bad droughts during dry spells. The supply of plant nutrients here is comparatively abundant. Where the glacial till is thin or absent, a condition encountered only locally, the soil on the limestone is generally very shallow, very high in lime, rich where it is not too thin, but very dry due to excessive drainage down through the natural solution openings (or "cavelets") in the soluble limestone.



GEOLOGIC MAP AND CROSS SECTION OF OHIO

In eastern Ohio on the other hand, the very permeable sandstone bedrock, where it is exposed, produces a very acid, low-nutrient substrate which is especially dry on the tops of the hills. Locally the sandstone crops out at lower elevations. Here, through it is also acid, it provides a supply of moisture that is continually both available and cool because it comes from springs, the water of which has percolated down through the permeable sandstone and emerged deep in the valleys without being sunwarmed. The shale present beneath the sandstone in some areas also produces a generally acid low-nutrient substrate. However, unlike the sandstone, it is impermeable. As a result surface water tends

to run off rather than soak in, making it an especially droughty substrate during prolonged dry spells. In addition shale may be present as layers within the sandstone; where this happens, the cool acid water moving down through the sandstone cannot extend deeper and emerges on the hillsides as springs. Where the sandstone is mantled by till, the amounts of clay and lime in the till result in less acid, more moist, and more nutrient-rich soils. The till which occurs near the margins of the sandstone area contains greater amounts of clay and lime, resulting in substrates more like those formed in the till of western Ohio.

Glacial gravels are the most permeable of all substrates so water availability is not determined by the composition of these materials, but by their relative elevation. Gravels at low elevations are commonly almost completely saturated, creating a high-moisture (and low-oxygen) substrate, whereas gravels at higher elevations are usually extremely dry (especially at the ends of long dry spells). Most Ohio gravel deposits contain abundant limestone pebbles providing a substrate high in lime; only far to the south of the glacial boundary and deep within the area of the sandstone hills is the increase in abundance of acid pebbles from local sources great enough to produce a really acid gravel substrate.

Plants vary greatly in their substrate requirements, and also in the range of their tolerances. Some plants — the "weeds" — have especially wide tolerances and will grow under almost any conditions, acid or limy, wet or dry. Other plants however have more narrow tolerances and therefore have distributions that are restricted, at least to some degree, by differences in substrate characteristics. A few occur only under extremely limited conditions. For a geologist wanting to use plants as keys to the recognition of certain geological conditions, or a botanist wishing to predict plant distribution on the basis of geological mapping, it is the latter group of plants that is the most useful and the most interesting.

Knowledge about which plants are so restricted in their substrate tolerances, and to exactly what substrate conditions they are restricted, is very incomplete, and reasons for these observed relationships are generally very obscure and little understood. This is mostly because of the small percentage of geologists and botanists working in this fascinating interdisciplinary field. Considerable work was done on these relationships by the late Dr. E. Lucy Braun, many of whose interpretations are preserved in her books (**Deciduous Forests of Eastern North America, Woody Plants of Ohio,** and **Monocots of Ohio**) from which some of the following material was drawn and to which the reader is directed. In addition, Dr. Ronald L. Stuckey, plant taxonomist on the faculty of The Ohio State University and Curator of the Herbarium there, is presently directly a very active program of study involving the distributions of a large number of individual species of Ohio palnts. Much of the following information has been drawn from data provided by him, especially with regard to the herbaceous species, and he has kindly provided the distribution maps of the selected plant species accompanying this paper.

Substrates of course do not provide the only control on plant distribution. Climate, especially its rather restricted local variations (microclimate), and the past history of the land are also critical, although their influence is essentially ignored

in this article. Actually the geologic substrate also has an effect on the microclimate, and geologic history contributes a significant part of the past history of the land, so the importance of geologic factors in controlling plant distribution should not be underestimated.

Plants that have a distribution generally limted to limestone or limy substrates are perhaps best known. These include

Trees & Shrubs

redbud (**Cersis canadensis**)
red-cedar (**Juniperus virginiana**)
frangrant sumac (**Rhus aromatica**)
hackberry (**Celtis occidentalis**)
blue ash (**Fraxinus quadrangulata**)
hawthorn (**Crateagus mollis**)
chinquapin oak (**Quercus muehlenbergii**)
hop hornbeam (**Ostrya virginiana**)

Herbs

sedge (**Carex eburnea**)
flat-stemmed spike-rush (**Eleocharis compressa**)
snow trillium (**Trillium nivale**)
two species of white bluets (**Houstonia nigricans** and **H. longifolia**)
herb Robert (**Geranium robertianum**)
nodding thistle (**Carduus nutans**)
cordate-leaved plantain (**Plantago cordata**)

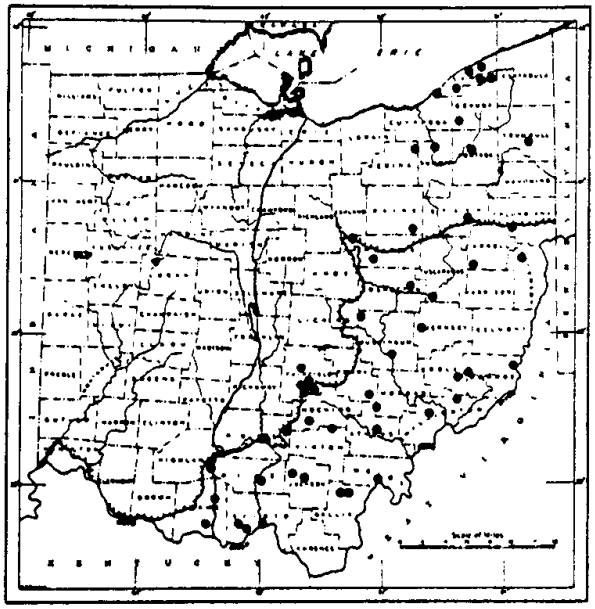
Redbud, red-cedar, and fragrant sumac generally seem to occur on higher, drier sites where limestone is present at only very shallow depths below the ground surface (though there are a few unexplained sites in southern Ohio, near Pike Lake, where redbud is present apart from any limestone substrate, and red-cedar also occurs in non-limy places where the soil has been destroyed). Hackberry, although it occupies similar high, dry sites on limestone bedrock in the Erie Islands, is more common along floodplains in most of Ohio (perhaps because the water percolating through the relatively permeable floodplain deposits is high in dissolved lime). Blue ash occurs in greatest abundance on the limestone substrates of the Erie Islands, but is present throughout the area of high-lime tills of western Ohio (and locally in a few spots in east-central Ohio where the glacier transported lime-rich till farther east, as shown on the accompanying map showing the distribution of blue ash). This distribution of blue ash, extensive in the area of high-lime substrates in western Ohio but lacking in the acid substrates of eastern Ohio, is strikingly illustrated by the map showing the distribution of this species. The hawthorn listed above is an old-field species which occurs in very dry, disturbed (by man) sites, and which appears to be really abundant only in places where the limestone bedrock is quite shallow. The last two trees on the list, chinquapin oak and hop hornbeam, are species which are more common on limestone or limy substrates, but whose distributions are not limited to such sites. The herbaceous species listed above all have distributions closely related to the presence of shallow or exposed limestone bedrock, according to field data supplied by Dr. Stuckey.

Trees which characteristically are present on the high-lime, clay-rich substrates developed in the thick till of the western Ohio plains are not included among those in the list above, although blue ash is an occasional representative. Most common of the tree species occurring on these till plains are: sugar maple (**Acer saccharum**), beech (**Fagus grandifolia**), red oak (**Quercus borealis**), shagbark hickory (**Carya ovata**), together with white oak (**Quercus alba**) on somewhat drier sites, white ash (**Fraxinus americana**) in slightly wetter places, and swamp white oak (**Quercus bicolor**) and pin oak (**Quercus palustris**) where standing water may last for several days or weeks. These are the forms which make up the major species compositions of the common plant communities of glaciated Ohio as shown by Gordon on his map of the **Natural Vegetation of Ohio at the Time of the Earliest Land Surveys.**

Another tree that also occurs on the till plains of western Ohio is apparently there for a reason other than substrate. This is bur oak (**Quercus macrocarpa**), the prairie-margin tree. This species, which occurs abundantly along the eastern margin of the great prairies farther west in the United States, was also present along the margins of the small islands of prairies that were found in Ohio when Europeans first came into the state, and is still relatively abundant in these areas.

Another single species of particular interest is **Sullivantia sullivantii,** a small herbaceous plant in the saxifrage family, whose distribution is restricted to continually moist (commonly dripping), shaded rocky cliffs south of the glacial boundary (see accompanying map). Most of Ohio's preglacial cliffs have been buried by till. Only in a few scattered places in southern Ohio are such sites still present, and it is in such sites that the few occurrences of this species are located.

On the sandstone hills of eastern Ohio where acid, locally very dry substrates are characteristic, a totally different set of species is encountered. These include the following:



Distribution of chestnut oak (*Quercus montana*) in Ohio. Hachured line is glacial boundary and solid line separates area of limestone to west from area of sandstone (and shale) to east. Sources of data are specimens in The Ohio State University Herbarium and records compiled by E. Lucy Braun for her book, "The Woody Plants of Ohio."

Trees

chestnut oak (**Quercus montana**)
sourwood (**Oxydendrum arboreum**)
scrub pine (**Pinus virginiana**)
pitch pine (**Pinus rigida**)
hemlock (**Tsuga canadensis**)
mountain maple (**Acer spicatum**)

Shrubs & other small woody plants

mountain laurel (**Kalmia latifolia**)
huckleberry-blueberry (**Vaccinium ssp.**)
trailing arbutus (**Epigea repens**)
greenbrier (**Smilax glauca**)

Herbs

pink ladies' slipper (**Cypripedium acaule**)
ill-scented trillium (**Trillium erectum**)
smooth Solomon's Seal (**Polygonatum biflorum**)
bellwort (**Uvularia perfoliata**)

The tops of hills, which have the driest substrate, are where most of these plants --the first four trees (chestnut, oak, sourwood, and the two pines), the two shrubs, and the three herbs--occur. Distributions of these species are thus restricted to areas of shallow or exposed sandstone bedrock, generally outside the glacial boundary (even within but near the glacial boundary there are many places where the till is so thin that sandstone bedrock is exposed and these plants are present). A good example is chestnut oak, whose distribution is shown in an accompanying map. This plant, whose occurrence is limited to the tops of high, dry sandstone hills, is predominantly a plant of the unglaciated hills. Its existence north of the glacial boundary indicates the presence of such high, dry sandstone hills there, hills which must completely lack any of the till cover generally found elsewhere in glaciated Ohio.

Sweet buckeye is one of a number of species (like white basswood, **Tilia heterophylla**) which does not occur anywhere inside the glacial boundary, as demonstrated by its distribution on the accompanying map. The reasons for such restrictions in distributions are not known, but may have something to do with problems of repopulation, by these plants, of the clayey, high-lime glacial tills in the short time since the ice left Ohio. Why this plant does not extend even as far north as the glacial boundary in eastern Ohio (in Holmes, Stark, and Columbiana counties) is also not clear; perhaps climate is the controlling factor here, for no geologic discontinuity is known along the edge of its distribution (in Muskingum, Guernsey, and Belmont counties).

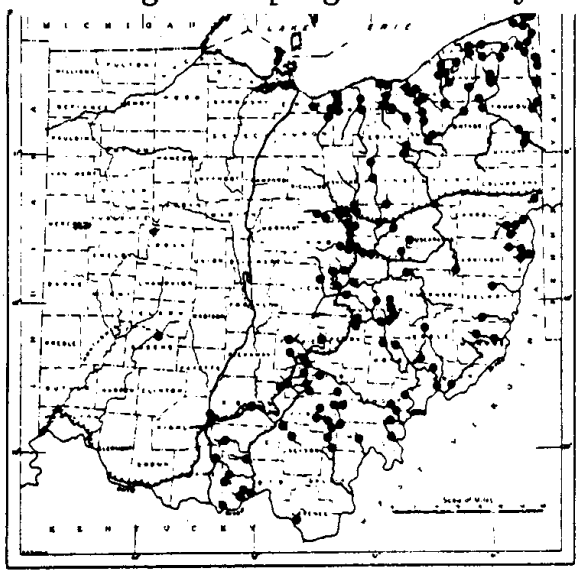
Hemlock is also present in unglaciated eastern Ohio, but its distribution extends far to the north, well north of the glacial boundary in that area, as shown by the accompanying map. The reason for this more extensive distribution appears to be its restriction to continuously cool, moist environments such as are found in the bottoms of deep valleys cut into sandstone and watered by cool spring water in the south, or such as occur in valleys in the north which contain some till but remain cool and moist because they are deep and open to the north. Apparently even though till thicknesses are generally greater north of the glacial boundary, resulting in somewhat less acidic soils, the cool moist north-facing valleys are adequate for hemlock to be present. The contrast in distributions of a plant restricted to unglaciated areas (sweet buckeye) and a plant occupying moist valley-bottom sites in sandstone (hemlock) is well demonstrated in the maps showing the distributions of these two species.

Tree species in unglaciated Ohio are not limited to those in the above list; these (except for mountain maple) are only those species characteristically present on high, dry sandstone hilltops, or in the perpetually moist cool valleys characteristic of sandstone bedrock (hemlock). More mesic conditions are abundantly present,

made moist because of the presence of impermeable shale layers in the bedrock; because of cooler, north-facing slopes; or because of moist forest-induced microclimates. Here occur many different tree species, comprising the mixed mesophytic forest as characterized by Dr. E. Lucy Braun. This group of species owes its distribution mostly to past history--their evolution in the Appalachian highlands and their elimination inside the glacial boundary—and only in part to variations in the substrate. Mountain maple is an example of one plant found in the mixed mesophytic assemblage which has a distribution restricted to the areas of sandstone, through only to the more mesic sites.

Areas of shale bedrock are either steep, where capped by sandstone, or low and flat. Whre they are steep, the hilltop species are those characteristic of the dry acid sandstone and the lower slopes are vegetated by species tolerant of dry acid substrates and prolonged droughts—many of the species listed above for the sandstone, but also including shingle oak (**Quercus imbricaria**). Where the shale is low and flat, it is generally covered by till, so the plant species present are those characteristics of a somewhat more lime-rich soil.

There are some plant species present south of the glacial boundary whose distribution might suggest that they belonged to the mixed mesophytic association in Ohio, even though they do not occur everywhere throughout the unglaciated area. An example of these is rhododendron (**Rhododendron maximum**). Only when its distribution is compared with the location of the valleys in the ancient Teays system (see map showing distribution of this species) does a possible explanation emerge. This species, according to Drs. E.N. Transeau and John N. Wolfe, represents one of several that lived (and still lives) in the Appalachian highlands and which migrated down through the preglacial Teays River system from that area north into southern Ohio. Subsequent glacial advance blocked the Teays River drainage and destroyed most of its valleys in Ohio, but the plants, whose distributions in Ohio were determined by this avenue of migration, still remain, living south of the glacial boundary and near the locations of some of the main valleys of that ancient river.



Distribution of hemlock (*Tsuga canadensis*) in Ohio. Hachured line is glacial boundary and solid line separates area of limestone to west from area of sandstone (and shale) to east. Single Greene County record is from Clifton Gorge, a cool moist valley; apparently the cool moist environment is more critical than any influence of the limy bedrock. Sources of data are specimens in The Ohio State University Herbarium, records compiled by E. Lucy Braun for her book "The Woody Plants of Ohio," and records from map showing "forest types with hemlock" prepared by E. N. Transeau, 1950, and published on page 31 in R. B. Gordon's book on "The Natural Vegetation of Ohio in Pioneer Days" (1969, Ohio Biological Survey 3(2):1-113).

North of the glacial boundary, where till mantles the sandstone bedrock only thinly, most of the species in the above list persist. Where the till cover is thicker, however, especially near the margins of the area of sandstone and in the areas of shale, the substrate is more clayey and more limey, so that some of the same species of trees found on the till plants to the west are present: sugar maple, beech, red oak, white oak, and hickory. In the east, however, the number of species is greater, for poorly

drained sites may also have white ash, red maple (**Acer rubrum**), or swamp white oak, and drier sites contain black oak (**Quercus velutina**) or shingle oak.

No list of species is presented for gravel substrates. This is mainly because of both the wide variation in acidity present throughout the areas of gravel and the great differences in available soil-water conditions when this substrate occurs at different elevations. Information about the plant-substrate relations here is also very inadequate. Indeed none of these lists is either complete or beyond question; there just has not been enough work done. In addition, as stated earlier, any attempt such as this to correlate plant distributions only with substrate ignores other important factors influencing the occurrence of plant species. The remarkable fact is that, in considering this one factor, there appears to be such good correlation with such a significant number of plants.

An important concept emerges from all this discussion: geologists and botanists now active in this area of research are needed, geologists who will learn enough about plants and botanists who will learn enough geology to make some real contributions. Once additional competent scientists are involved in collecting more information in this area of research, exciting new correlations may be made to extend greatly the already significant contributions of this new and challenging field of Geobotany.

This article has been reproduced from The Explorer Magazine, Fall 1971, with permission by the author.

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Jean Andrews, Athens Chapter Contact

WILD GINGER - One of Our Best Known Wildflowers

Wild ginger (**Asarum canadense** L.) has been selected by the Athens Chapter of the Ohio Native Plant Society for the Society's wildflower poster, now available at selected locations in Athens, Marietta and Nelsonville (see related article this issue).

The genus **Asarum** has about 100 species that are perennial herbs with vestigial or no petals. Many species are cultivated for their curious flower shapes and often colorful variegated leaves. The leaves are generally covered with soft, wooly hairs forming a velvet-like surface. The flowers appear in early spring and vary greatly in the shape of the lobes. Wild ginger (**Asarum canadense L.**) is an inconspicuous, but fragrant member of the genus that is found in rich, rocky woods and on the steep slopes of southeastern Ohio. It is common throughout the state (except Pickway County) and grows from southern Canada south to Georgia.

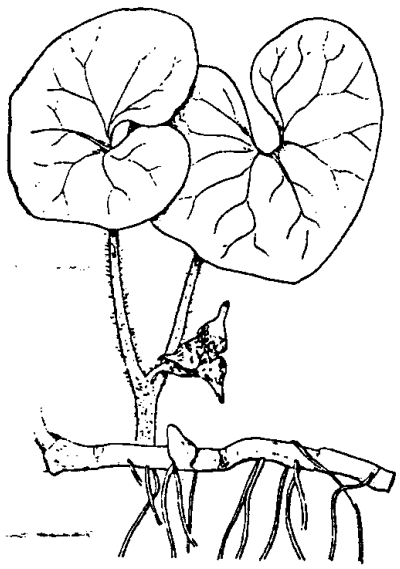
Plant experts have described the fascinating reproductive strategy of wild ginger as much like that of the curious little arum lily, **Arisarum proboscideum.** The strategy was first formulated a hundred years ago by the highly esteemed Italian botanist Arcangeli as a pollination case so 'unbelievable' that even his friends began to fear that he had fallen prey to early senility. Arcangeli claimed that the arum lily mimicks the underside of the cap of a mushroom so successfully that the female fungus-gnats

are fooled into depositing their eggs in or on the flower instead of on decaying mushrooms! Getting down more deeply into the floral chamber they will also pollinate the plant. In the case of wild ginger, the larvae from the eggs start eating almost immediately, but the flower tissues are so poisonous that the young animals die very quickly. This unusual reproductive strategy has been described as 'ruthless' exploitation of a pollinator by a plant.

Research in the 1960s and 1970s seemed to vindicate Archangeli. Many of the wild ginger plants studied contained fungus-gnat eggs and larvae. But recent field studies suggest that pollination can occur for a very brief period of one week, after which the stamens completely envelope the stigma and the plant self-pollinates. Consequently, further studies are needed before firm conclusions about wild ginger pollination can be made.

If fungus-gnat larvae do not benefit in the least from their association with wild ginger this is certainly not the case for humans. Although a few cases of dermititis from contact with the leaves have been reported, Native Americans often used the rhizome of the wild ginger to disguise spoiled meat and to flavor food. In Canada a preparation of the plant served as a remedy for heart palpitations for some tribes. In 1837 this heart medicine was offered to Dr. Stephen Williams of Deerfield, Massachusetts, who said he offended the Natives when he refused it. Native American and pioneer women liked wild ginger for another reason - they favored it to induce a normal menstrual cycle. Wild ginger has been prescribed in folk medicine to ease intestinal and stomach gas, to promote sweating to break a fever, and as a tonic and appetite stimulant. The rootstock has been used as a substitute for commercial ginger.

Famous people have noted the medicinal use of wild giner. Meriwether Lewis, in **The Lewis and Clark Expedition, 1804-1806** wrote: "...One of the hunters in attempting to mount his horse, after shooting a deer, fell on a small piece of timber, which ran nearly two inches into the muscular part of his thigh...The gentlest and strongest horse was therefore selected, and a sort of litter framed in such a manner as to enable the sick man to lie nearly at full length...Soon after they passed another Indian fort on an island, and after making nine miles, halted to let the horses graze, and sent out a hunter to look for timber to make a canoe, and procure, if possible, some wild ginger to make a poultice for Gibson's thigh, which was now exceedingly painful."



Wild Ginger (Asarum canadense), *a species which is common is southeastern Ohio*

Aside from its past medicinal uses, wild ginger is an attractive plant that many people have cultivated in their gardens. Writes Lewis Gannett: "...Why the hills about us are not all carpeted with wild ginger is a deep mystery. Three small plants which we set out fifteen years ago have each spread...one of them reached down through

a stone wall...We like wild ginger. Its rusty hidden flower makes a lovely design, though you have to stoop to see it...and it blooms, in its modest way, almost as early as bloodroot and arbutus. But enough is enough. For years now we have been weeding wild ginger and trying to give it away to friends who complain that nothing will grow in their dry soil."

Wild ginger is used as a landscape plant that can be easily propagated in the spring by dividing the rhizomes. It can be used effectively as a ground cover or edging plant in shaded areas and is relatively pest free.

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PROTECTING OHIO ENDANGERED PLANTS: THE BIG TASKS ARE AHEAD -

by Robert McCance, Jr.

Ohio has one of the most accurate state endangered plant lists in the country. For twelve years botantists of the Natural Heritage Program, as well as many other professional and amateur botanists and naturalists, have searched for and found rare Ohio plants. There is a considerable, but unstudied, difference between the first draft rare plant list developed by a committee of the Ohio Biological Survey in 1976, and the fifth version of the official Ohio endangered plant list developed for implementation by the Chief of the Division of Natural Areas and Preserves in 1988.

February 1989 information on the protection status afforded to these species indicates that a great deal of work lies ahead. Currently there are 178 plants listed as state endangered, and they are represented by approximately 700 records in the Natural Heritage date base. These records include, but are not limited to, information on the age of the record, its location and locational accuracy, the known quality or quantity of the population, and the protection status afforded to the site. Ideally,

we would like to see each plant have excellent or good quality populations located at protected sites with information current to within ten years. We are a long, long way from that status. Some things we can do very little about with our available resources. Since we are concerned about naturally occurring populations, we will never have good populations of all endangered plants. Exactly half of the plants have at least one occurrence that is judged to be an excellent or good population. The other half of the species may also have populations of this quality, but they have not been investigated recently enough to be confident of their status. Many of the older records, if they provide population information at all, merely say such things as "scattered", "rare", or "infrequent". This is not sufficient to determine which Ohio populations are best, or how large or healthy they are.

Staff botanists have assigned units to be quantified for each rare species (these lists are available upon request) so that each person providing data will put it into the same units. "Plants" can be a very misleading term when one person counts flowering stems and another counts clumps. We have been making an effort to update and improve the information on endangered plants, but it is time consuming and difficult, and in unusual years (drought of 1988!), we do not wish to use the population information that we collect on some species as reasonable estimates of the size of the population in normal years.

Of the plants that do have good quality populations, 48 (27% of the total number of endangered plants) have at least one such population on land that is considered to be preserved or protected (that is, land management is likely to protect the populations). Only 11 plants (6% of the total) have a good quality population on a state nature preserve, based upon date in the Natural Heritage computer data base in February, 1989.

Many things can be done to see that additional plants receive protection, and where feasible, assistance to, or enhancement of, their existing populations. Our first task is improving the quality of our knowledge of their distribution and population sizes and health. With information on species biology and their global rarity, we can determine which ones would benefit most from assistance, and where the assistance should be applied. Active landowner notification programs can assist in this effort. The Ohio Natural Landmark Program, operated by the Division, has helped protect the privately-owned occurrences of Running Buffalo Clover, a federally endangered plant. The Nature Conservancy's Ohio Land Registry Program has been granted voluntary protection agreements by landowners at over 150 sites in Ohio. Undoubtedly these efforts by both agencies help protect good populations of endangered plants, but those data are not currently included in our data base.

Rare plant monitoring and enhancement management may help turn some lower quality populations into better quality ones. These efforts usually occur at protected sites, so there are good prospects that more endangered plants will have good populations created by these efforts.

Although this information indicates that we have a long way to go before Ohio can claim to adequately protect its endangered plants, at least now we are beginning to get an accurate picture of the size of the task. That is the good news!

HOW FAST CAN TREES MIGRATE?

If the climate models are correct, greenhouse warming will spell doom for many forests across the United States. The forests in the south will go first. Seedlings will wither, the understory plants will be replaced. And over the next century or so, many now-abundant trees will go extinct across much of the United States.

Such are the predictions of Margaret Davis, one of handful of ecologists looking at the effects of the much discussed greenhouse warming on North American forests. As Davis and others who make these predictions readily admit, they are riddled with uncertainties. Data are scarce and have been cobbled together from fossil records, theoretical models, and experiments in controlled environments. Few long-term field studies have been done.

The critical question to Davis is how quickly trees can migrate, for the fate of numerous species in North America will depend on whether they can shift north to cooler climes when their current range becomes uninhabitable.

Speed is of the essence. If the various climate models are correct, within 100 years of earth will not only be hotter than it has been in 1 million years, but the change will be more rapid than any on record. During this time global temperatures are expected to climb 2° to 5°C, and each 1° rise in temperature translates into a range shift of about 100 to 150 kilometers. Trees can migrate long distances, as the fossil record shows, but can they do so in such a short time?

To address this question, Davis and her colleague Catherine Zabinski have focused on four hardwood species—eastern hemlock, yellow birch, beech, and sugar maple—that are widespread in the Great Lakes region of eastern United States. Highlights of this study were presented at a meeting sponsored by the World Wildlife Fund last fall. This work is also part of a larger Environment Protection Agency study, "The Potential Effects of Global Climate Change."

To forecast the future response of each species to climate change, Davis and Zabinski first had to figure out the climatic conditions that determine its current geographical range—essentially, a combination of mean January temperature, mean July temperature, and annual precipitation. With those data in hand, the Minnesota researchers then used two general circulation climate models to calculate where suitable climate for each species will be in the future, when carbon dioxide has doubled from preindustrial levels, the benchmark in calculating greenhouse effects. Doubled carbon dioxide roughly translates into a global temperature hike of some 2° to 5°C.

The GISS model, developed by the National Aeronautics and Space Administration, predicts elevated temperatures throughout the Great Lakes region and slightly increased rainfall. The GFDL model, developed by the National Oceanographic and Atmospheric Administration, shows even higher temperatures in the Great Lakes region, averaging 6.5° as opposed to 4.5°C under GISS, with a decrease in summer rainfall. Such estimates are uncertain, however. Although general circulation models provide reasonable estimates of overall climate trends, they are quite shaky on regional details.

The actual extent and rate of warming will depend, of course, on the future production of not just carbon dioxide but methane, nitrous oxide, and

chlorofluorocarbons, and on how the earth's climate will respond to those increases, which is not at all clear. Davis made the conservative assumption that the temperature increase equivalent to doubled carbon dioxide will not occur until 2090. Others predict that it will happen much sooner, perhaps by 2030 or 2040. Davis cautions that doubled carbon dioxide is just a "way station"; carbon dioxide will continue to accumulate, and temperatures will continue to rise, unless action is taken to curb emissions.

Whichever model is used, the results are striking. Both predict conditions under which tremendous northward range shifts—500 to 1000 kilometers—would occur for all four species. Under the milder GISS scenario, sugar maple would disappear across the sourthern edge of its current range, in a belt 200 to 600 kilometers wide in the middle of the country. Its range would shift eastward in Minnesota by about 100 kilometers, and new habitat would open up to the north, extending some 800 kilometers beyond its current range.

Under the more severe climate scenario predicted by the GFDL model, sugar maple would die out throughout its entire range, except in Maine, eastern Quebec, and Nova Scotia. New potential habitat would extend some 500 kilometers northward into Quebec. Similar patterns emerge for yellow birch and hemlock.

Beech would be hardest hit under either model. It now grows across a wide swath of the United States, from Georgia into southern Canada in areas of high rainfall. Under the GISS model, the population would drop precipitously and perhaps die out over a 1500 kilometer region in the eastern United States. A much smaller area of potential new habitat would open up in Canada. Under the GFDL scenario, beech would disappear from the United States, except in northernmost Maine, and a larger block of noncontiguous habitat would open up in Canada.

Davis cautions that these range shifts are approximate, given the uncertainties in the climate models and the assumptions she and Zabinski made about the species' physiological thresholds and the like. In addition, their calculations do not factor in many variables, such as the direct effects of carbon dioxide enrichment and competition among species, that could make a significant difference. "This is the general direction of change," says Davis, who urges that the details of the forecast nonetheless be "interpreted with a grain of salt."

For all four species, the toll would be greatest on forests near the southern limits of their current range. At first the changes would be subtle, barely detectable to the untrained eye. Almost as soon as temperatures begin to climb, beech, for instance, would produce fewer seeds and reproduction would decline. Within a few decades the vulnerable seedlings would wither and would be replaced by competitors more adapted to the altered climate regime. The hardy canopy trees would persist for many decades, however, giving the illusion that all is well.

Eventually, as temperatures climb and moisture decreases, adult trees would be affected directly, first failing to flower and fruit and eventually dying, though "it is difficult to predict the precise time course for tree death" they say. The most likely scenario is that the weakened trees would fall prey to insects or disease or would be felled by storms or fires, which are expected to increase in frequency under changing climate conditions.

In unmanaged forests near the southern limits of its current range, beech is unlikely to survive for more than 50 years after the onset of noticeable warming, Davis and Zabinski conclude.

Beech growing farther north, in the center of the current range, would get a four-or-five decade reprieve. Reproduction problems might set in by 2040, and trees would begin dying by 2090. Some beech would probably survive in the peaks of the Appalachians, where climate should remain suitable even after carbon dioxide has doubled. Trees will move upslope and perhaps thrive, they predict, provided there is adequate rainfall.

What will happen farther north, where the current and future range coincide? The prevailing assumption has been that beech will continue to grow there because the climate, though warmer, would still support them. But according to Davis and Zabinski, the answer is not so simple.

It all depends on how specifically adapted northern beeches are to the present-day climate in Maine, which Davis says is expected to shift to a climate resembling that of Georgia. Little is known about whether all individuals of a species can adapt to the full spectrum of conditions—varying day length, temperature, and the like—found throughout the entire range. There may instead be distinct ecotypes or subspecies adapted to local conditions and unable to survive in other parts of the range.

Beech, for one, appears to be highly specialized, with perhaps three distinct subspecies that grow in different regions of the country. If that specialization is hardwired in genetically, and if that holds true for other species as well, then the situation may be far worse than anyone has imagined, says Davis. In fact, survival of the species may hinge on transplanting the southern ecotypes to the north.

Davis calls for more research on this ecotypic variation and on each species' physiologic thresholds—actual studies in the field, which have been scarce. "You can put them in a greenhouse, but that is really irrelevant."

Perhaps the critical question is whether beech and other species will be able to migrate even farther north to the new habitats that will open up, or whether they will perish as suitable climate outpaces them.

When the climate began warming some 15,000 years ago, North American trees dispersed northward at a rate of about 10 to 45 kilometers a century, the fossil record shows. Beech, which is dispersed by jays, averaged about 20 kilometers a century. Spruce holds the record, 200 kilometers a century, when it migrated into Canada about 9000 years ago.

But what is different now is not just the magnitude of the predicted temperature hike, but the rapidity with which it will occur, which is at least an order of magnitude faster than any previously recorded. If the climate scenarios are correct, beech habitat will shift northward by 700 to 900 kilometers within the next century. That means beech would have to migrate 40 times faster than it did in the past, an unlikely prospect at best. If climate change is as rapid as predicted, Davis concludes, then long-lived species like beech will not make it without massive human intervention.

And just getting the seed there will not necessarily be enough. Whether a new

colony becomes established depends on not just climate but on the other types of vegetation present and on the soil chemistry, which is poorly understood at best. "It may fall to humans to convert the soil, in a massive and expensive intervention, if beech is to survive," Davis said at the World Wildlife Fund meeting last fall.

The changes Davis and Zabinski outline are not limited to eastern hardwoods; similar shifts would be occurring across the country for a variety of species, as a recent EPA report made clear. That report drew on six investigations, including this one by Davis and Zabinski.

Nationwide, EPA foresees a substantial loss of healthy forest area, which now accounts for 33% of U.S. land area, and a net reduction in U.S. forest productivity for several centuries. In the East, spruce and northern pine would decline in the southern parts of their ranges and expand northward. New England coniferous forests would be replaced by hardwoods, especially by oak. Southern pines might shift into the hardwood forests of eastern Pennsylvania and New Jersey. In the Southeast, some 18 tree species may become locally extinct, with forest lands being taken over by scrub or savanna.

In the West, the situation is not as bleak, as Douglas fir, ponderosa pine, and western hemlock can disperse upslope into the Rockies in California and Oregon, the populations of Douglas fir would shrink in the lowlands and be replcaed by western pine. If regional drought persisted and fires increased, total forested area in the West could be dramatically reduced and some species would go locally extinct.

Moreover, these projections are just for the lower 48 states, but as EPA points out, forest effects should be far more pronounced in Canada and Alaska, where the climate warming is expected to be greater. Large boreal forests "could be at significant risk," EPA notes.

All of these studies focus on the dominant canopy trees, for which there are adequate data. But as Davis and Zabinski point out, what happens to them will reverberate throughout the ecosystem. Each of the plants in the forest has its own physiologic tolerances and will respond differently to rising temperatures and changing rainfall patterns. They will scatter, perhaps in different directions, at their own speed. That means, for one thing, that forests as we know them will not simply be duplicated in the north; instead, new plant communities will emerge.

And, says Davis, if the situation looks grim for dominant canopy trees with abundant seed, it could be far worse for understory plants. Many woodland herbs, like **Trillium**, ladies' slippers, and trout lilies, produce few seeds and depend on the wind to scatter them. She calls their chance of dispersing to favorable habitats "disappearingly small."

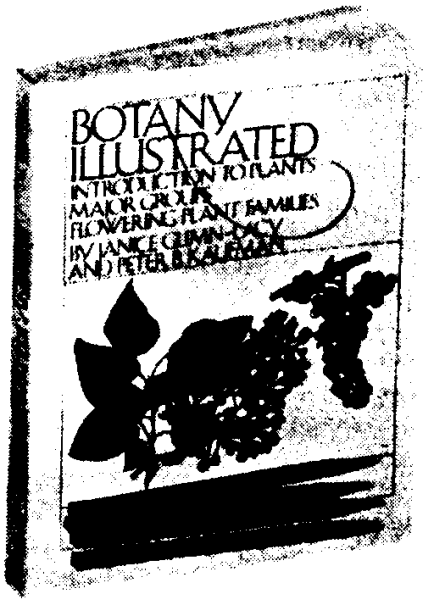
To save many of these species, Davis and Zabinski call for recreating entire forest ecosystems, including dominant trees, understory plants, and important animals, "on a large scale" in northern locations. They also call for setting up new refuges at all latitudes and for bringing wild plants into cultivation to preserve genetic diversity. EPA, too, envisions "massive reforestation" in the North and perhaps the introduction of subtropical species in the Southeast to replace the forests that have disappeared.

This has been reprinted from **Science, February 1989, Vol. 243.**

BOTANY ILLUSTRATED

INTRODUCTION TO PLANTS
MAJOR GROUPS
FLOWERING PLANT FAMILIES

JANICE GLIMN-LACY
AND
PETER B. KAUFMAN



This easy-to-use book helps you acquire a wealth of fascinating information about plants. There are 130 pages with text, each facing 130 pages of beautiful illustrations. Each page is a separate subject. Included is a coloring guide for the realistic illustrations. The illustration pages are composed of scientifically accurate line drawings with the true sizes of the plants indicated. Using colored pencils and the authors' instructions, you can color the various plant structures to stand out in vivid clarity. Your knowledge of plants increases rapidly as you color the illustrations.

Botany Illustrated has three sections. An *Introduction to Plants* gives you facts on everything from cells to seeds. The *Major Groups* section is from bacteria to fungi, algae, ferns, conifers and flowering plants. In *Flowering Plant Families* are magnolias to asters, and water-plantains to orchids, with the families of major interest included. You will find plants used for food, ornamentals, lumber, medicines, herbs, dyes, and fertilizers, whether wild or poisonous, or of special importance to our Earth's ecosystem.

Topics that will be of interest to you include:

- Why leaves 'turn' color in autumn
- How certain plants devour insects
- How a flower develops into a fruit with seeds
- Why some plants only flower at certain times of the year
- How water, nutrients, and sugars move within a plant, including tall trees
- How flowers are pollinated
- The 'inside' story of how plants manufacture their own food
- How plants are named and classified
- How vines 'climb'
- Why 'pinching' makes plants 'bushy'
- How plants reproduce sexually
- Why shoots grow towards light
- How specific leaf colors can indicate specific mineral deficiencies

About the Authors

Janice Glimn-Lacy, B.S. Botany, is a graduate of the University of Michigan. Since 1976, she has been a free-lance botanical illustrator and is Instructor of *Botanical Drawing and Illustration* for The University of Michigan Matthaei Botanical Gardens Adult Education Program.

Peter B. Kaufman, Ph.D. Botany, obtained degrees at Cornell University and the University of California, Davis. Since 1956 he has been at the University of Michigan where he is a plant physiologist, Professor of Biological Sciences, and currently doing research in space biology for NASA.

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