Winter 1984–85

arnoldia

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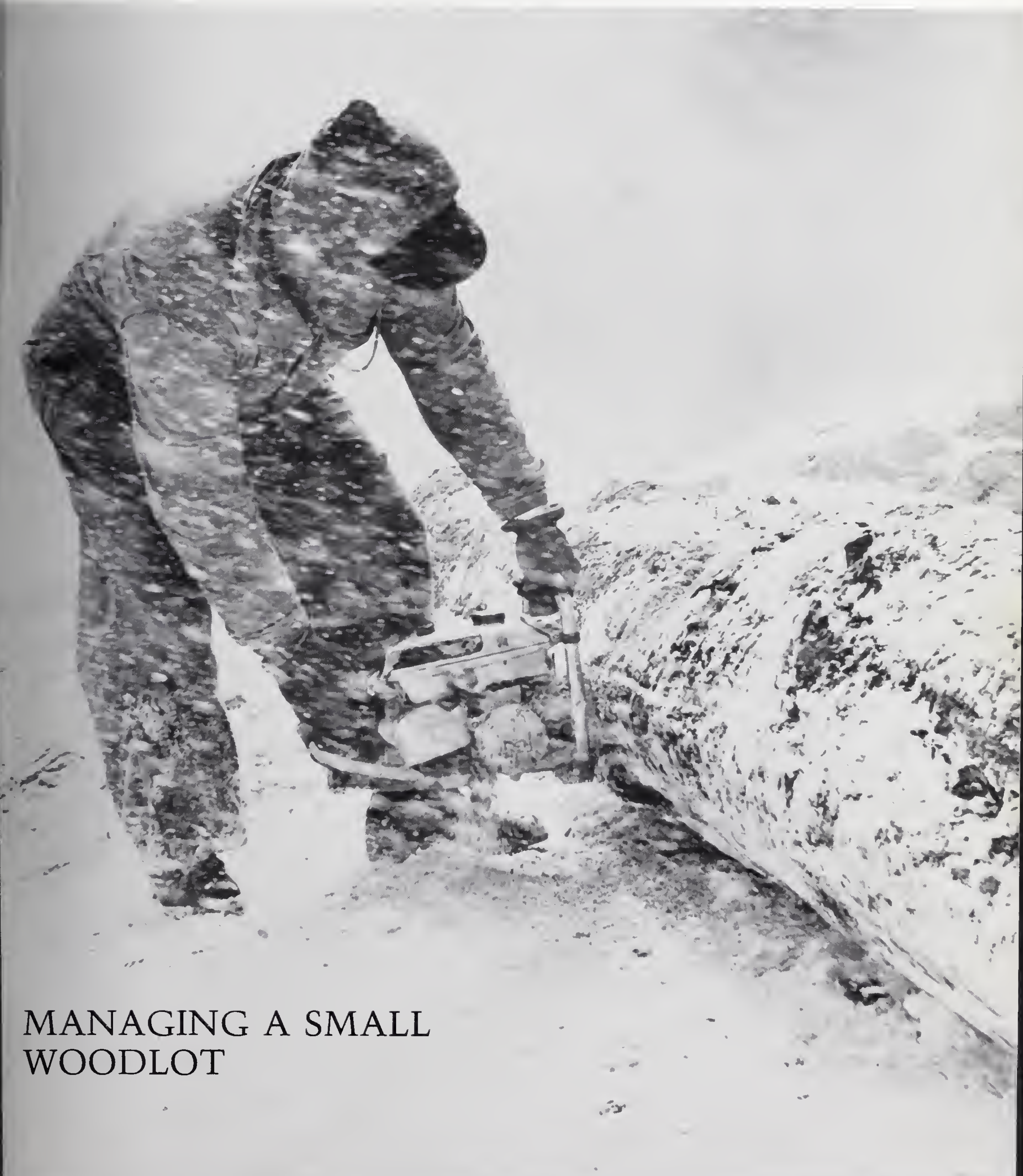

MANAGING A SMALL WOODLOT

Vol. 45 No. 1 Winter 1984–85

arnoldia

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Edmund A. Schofield, Editor

Peter Del Tredici, Associate Editor

Front cover: Winter logging in a Vermont woodlot. (See "Managing a Small Woodlot," page 3.) Photograph by R. Norman Matheny. Courtesy of *The Christian Science Monitor*. *Opposite: Cornus canadensis,* the bunchberry. Is it really just "a flowering dogwood (*C. florida*) lying on its side, growing horizontally through the litter rather than vertically"? See page 19 for Peter Del Tredici's answer to this intriguing question. Photograph by Peter Del Tredici. *This page: Phlox amoena* as depicted in *Curtis's Botanical Magazine* in 1810. (See "Collector's Notebook," page 25.) *Back cover:* The Arnold Arboretum in winter: beech boughs after a gentle snowfall. Photograph by Pamela Bruns.

Page

Managing a Small Woodlot

Ernest Gould

A professional forester urges woodlot owners to know and care for their land

I became a woodlot owner by accident because we were making a property map for the town of Petersham, Massachusetts. As you might expect, there were problems. We had trouble locating a number of tracts, and one owner, who lived in Florida, wanted to sell out. He'd bought the lot cheap 15 years before, "site unseen" as they say. All he knew for sure was that the northeast corner was 19 feet south of a big boulder and that the tax bill called for 48 acres. The deed itself was coyly reticent about everything except that northeast corner and about who the abutting neighbors had been a century or so earlier. In addition, I knew that two friends of mine hadn't been able to pin down the boundaries in their spare time over the previous year.

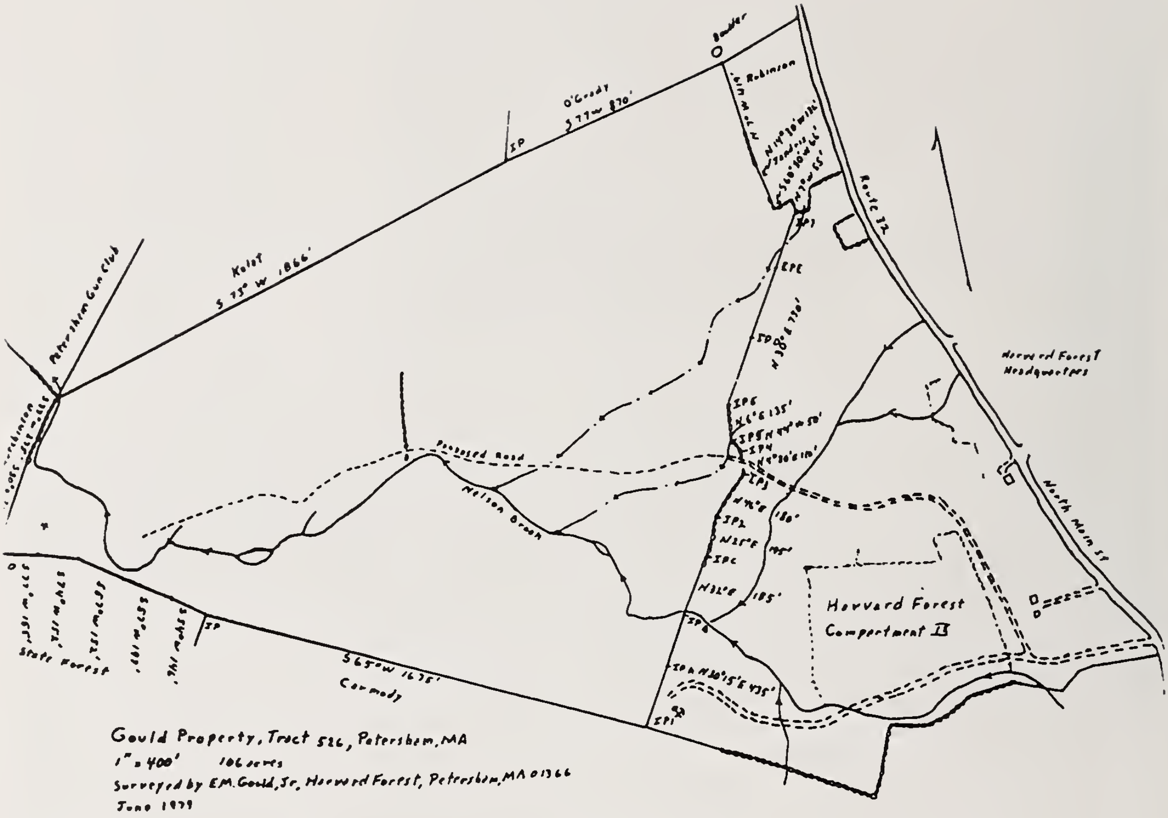
All in all, it looked like a real gamble as to where the land was, and how much of it there was, so we struck a bargain, and I started hunting. Nothing made much sense on the ground until I traced the deeds back to the old Stratton farm and could follow its breakup through inheritance and sale over the next hundred years. Then I knew where to look for corner and line markers of pipe or "stake and stones" and, because most of my land had once been fields, how to interpret stone walls in the woods, bits and pieces of barbed wire sprouting out of trees, and old cutting boundaries. Working this out became a three-year, spare-time hobby that eventually required pinning down two equally vague neighboring properties.

After all that, you can bet I have well-painted bounds with iron pipes set at each corner and even at intervals on the longer straight lines. Each year I blaze, paint, and brush out a bit of the boundary so that there is no confusion. As Frost said, "Good fences make good neighbors," and a well-marked boundary makes it hard for a logger to "accidentally" cut over the line. Most states award triple stumpage, the value of a tree standing in the woods, for trees "knowingly" cut on the wrong land, so it saves grief to let people know just where your land begins.

Mapping the Bounds

This was the time to make a map of the place. With a pocket compass, a tape, and my nephew, it was easy to get the distance and direction of each boundary line and then plot it up. There is a good description of how to do this in the *Boy Scout Handbook.* I've found that a scale of about 400 feet to the inch is useful; it allows reasonable space to plot details, and most maps aren't too big to go on a standard piece of paper that fits into normal files. I make the original in pencil and, when I'm satisfied, finish it with black ink. I then have a master that's easily reproduced with a Xerox, and having cheap copies makes it possible for me to use the map freely for records of all kinds. In fact, such a map is the main place where I note all sorts of information that makes owning my woodlot fun.

Once I knew exactly where it was and had an outline map of it, I wanted to know more about my land. In the course of chasing boundaries I had



The bounds mapped and the permanent features paced.

already found an overgrown road and a brook. Also, I had found that red maple swales bordered two substantial segments of the stream and that these had apparently been clear-cut for fuel about 25 year before.

The trees are now four to eight inches in diameter, are closely spaced, and run heavily to stump-sprout groups. In fact, a thinning for stove wood could now be made, and the residual would grow faster.

The rest of the area had some nice red oak here and there, growing in mixture with other hardwoods or above an understory of hemlock. A few of the oaks were already 18 to 24 inches in diameter and readily salable. But I really needed to know more precisely what was there and where it was before deciding what was best to do.

Pacing the Permanent Features

When I had finished working on the boundary and the time came to look inside to see what this piece of real estate contained, I learned to pace. Pacing is almost a lost art that anyone can learn because it simply takes practice but, like riding a bicycle, once you've acquired the skill it stays with you forever. Again, the *Boy Scout Handbook* was a handy reference and about the only one I knew that was readily available. So, with map in hand, a compass, and my natural stride, I started to fill in the permanent features of my woodlot's topography.

I began with my overgrown logging road and discovered that it was well worn and needed little work to clear up to a stone wall and then a bit

With a little clearing and a load or two of gravel for the wet spots, a revived logging road makes the easiest trail into a woodlot. Photograph courtesy of the New England Forestry Foundation.

beyond, to one of the streamside swales of red maples. This part was probably a farm lane that old man Stratton had laid out to get to what one of the deeds calls the "long mowing." In the early days wet swales were cleared and used to cut hay from the natural grasses that took over once the sprouts were killed off. The road continued on but gradually became more overgrown and diffuse, so that it looked like a skid road used occasionally for logging. Judging from the old pines lying across it, which probably had blown down in the hurricane of 1938, this part of the road had been abandoned for over 40 years. Finally, even this trace disappeared some distance short of the back boundary. Primitive as it was, the old road was still the easiest trail into the lot; it seemed well enough laid out that it was stable and not eroded and, with a little clearing and a load or two of gravel in wet spots, would be easy to revive.

With this landmark in, it was logical next to map in the brook that paralleled much of the road. Doing the main stream and pacing the tributaries, I located all the permanent and intermittent streams that flowed over the lowest land containing all the wet spots that markedly influenced growth or gave trouble with roads. I also sketched in the drainage pattern on which the higher land was hung. With the valleys done, it was easy for me to locate the ridges and knolls and to note which were steep and which gentle.

Oaks tend to occupy the dry ridge tops. Shown here in flower is *Quercus rubra*, the red oak. Photograph by Albert W. Bussewitz.

Mapping Tree Cover

With the topography roughly filled in, I had also defined the main growing sites with moisture regimes different enough to be reflected in the growth of the trees. The wet swales were dominated by red maple, while, at the other extreme, the dry ridge tops were given over to oak. The slopes between had mixtures of hardwood with a pine here and there, while some of the gentlest slopes with diffuse, intermittent streams had a lot of hemlock under the hardwoods. Now I could start to make some sense out of the forest cover and get a feel for where things would grow. The woodlot began to take on natural form and organization.

The distinctive bark of the yellow birch, *Betula alleghaniensis,* is an aid to its identification in winter. Photograph by Barth Hamberg.

Immature cones of the American larch or tamarack, *Larix laricina,* a species that thrives in valley-bottom bogs. Photograph by Albert W. Bussewitz.

Of course, I knew the local trees because of my training, but many owners must start from scratch and learn to identify the different species. This is relatively easy: with a good field guide and a bit of practice one can quickly identify the main leaf shapes in the summer and the buds and twigs in the winter. In addition, many trees have a distinctive bark form, color, or texture that is easily learned. In any case, learning the trees is the first step toward understanding what you see in the forest because the trees "integrate" the natural growth capacity of each site, telling you something about the local microclimate and about conditions below ground.

Although red maple, for instance, grows

everywhere as scattered individuals, it will totally dominate sites too wet for other trees. Yellow birch is more plentiful on moist sites and doesn't start in big openings exposed to the hot sun. While white birch can't stand the wet, it can dominate sunny cut- and burned-over sites just as well as the pioneer, short-lived gray birch and trembling aspen. White pine in central New England also grows almost everywhere, but forms pure stands in abandoned fields and pastures. Being the first step back toward forest in such places, it is succeeded by hardwoods on all but the driest sites, such as sand and gravel plains. At the other extreme, the wettest sites are the bogs

The short-lived gray birch, *Betula populifolia,* shown here, and the quaking aspen, *Populus tremuloides,* as well as the white birch, *B. papyrifera,* occupy sunny cut- and burned-over sites. Photograph from the Archives of the Arnold Aboretum.

that in central New England support sphagnum moss on the ground and black spruce, tamarack, and the odd red maple overhead, with here and there a white pine on a sandy knoll. This complex of species seems able to withstand the short growing season in these valley-bottom bogs, but it grows very slowly and is probably most valuable for managing watershed and wildlife, especially birds.

Managing the Woodlot

One of the popular myths about private landowners like me is that we butcher our woods and mistreat them more often than any other group of landowners. I doubt we do, however, because so many owners I've met are like me in wanting to take care of their woodlots. Also, year after year official estimates show them producing their fair share of the cut, fair in the sense that they own about half the land and cut about half the wood. In addition, their growth and harvest make about as high a percentage return on their inventory of standing timber as do industry's, and much better than government's. This may simply mean that the woodlots continue to produce in spite of neglect, or perhaps that "management by accident" is more effective than professionals believe. In any case, trees grow without much attention for a great many private owners.

But is this the best way to enjoy and profit from a woodlot, and to be a good neighbor? In most cases, no! Following a few simple rules will bring you greater ownership satisfaction from the land and, at the same time, will benefit your descendants and the public at large. In the past it was not uncommon to hold a woodlot, let nature take its course, and, every couple of generations when prices were high, "lumber it off." And that still happens. But today owners have come to have a high regard for a wide array of values, including outdoor recreation, observing wildlife, hunting, relief from the work-a-day life, gains from rising land values, aesthetics, a source of fuelwood, and a host of other satisfactions that are generally not traded over the counter.

Yesterday, when land was cheap and interest and taxes low, most folks didn't worry about getting the most out of their woodlands. Today, everything is dear and high carrying costs make owners more cautious and thoughtful, so there is a renewed interest in land management, especially in steps aimed at a balanced mix of those tangible and intangible returns.

But time and money are scarce. How should one ration them in managing a woodlot? Normal prudence suggests investing them first in the venture that gives the greatest return in cash or satisfaction, second in the next-best earner, and so on. The greatest satisfaction from owning a woodland comes from the initial purchase, because that entitles you and yours to any and all present and future benefits. The next-best return is from investments to safeguard the forest —

A road and trail net is essential for access to all parts of a woodlot. Photograph by Hope Wise.

good boundaries, access for fire control, taxes paid, and the like. For most, the third-best payer is a road and trail net by which to get around and enjoy one's woods. Finally come investments in management that will improve forest production of goods and services of all kinds. Often, much of the road-net and management cost can be internally financed from the proceeds of a sale when you have suitable timber.

People who never really cared much for management are suddenly doing something very positive as they look to their land as a means of keeping the wood basket full. In fact, a common question these days is, "Where can I buy a woodlot, and how many acres must I have to grow enough firewood for the house?"

Cutting the Timber

If you want to accomplish all this and get some roads and trails onto your property, it usually will be necessary to make some kind of cutting. The time to do this is when you need the wood or when the market is brisk. Your problem may be how to find out about the state of the market. One thing you can do is to call the service forester in your county and ask him or her about it. Part of a forester's job is to advise private landowners, and because foresters are paid by the state you get such services free. Because there is no charge, don't expect too much attention as the competition for his or her services is understandably stiff. Or, you can buy the time of a consulting forester, but be sure to ask about fees before you start. If it turns out that you are going to make a sale of timber, then it is very important to get a trained person to look after your interests.

The next most important thing is to have a written contract with the logger so that both of you will know what to expect. Most people don't know what should be covered by a contract, but you can call the extension forester at your state university, and he or she will send you some samples. Or you can get advice from your consulting forester. The rules (see "If You Decide to Cut" page 10) give an idea of some of the considerations that should be given attention in logging. They may give you a small start toward a more satisfying relationship with your woodlot.

A forest economist, Ernest Gould is assistant director of the Harvard Forest in Petersham, Massachusetts.

IF YOU DECIDE TO CUT

•KNOW THE LAW. Most states have laws that govern the cutting of trees. Massachusetts has a Forest Cutting Practices Act, for example, which requires a landowner to file a notice of intent to cut, and a cutting plan before most timber sales. Everyone in the business of logging must get a commercial harvester's license from the state. There is also a Slash Disposal Act, which is administered by the state fire wardens. In addition, local conservation commissions in Massachusetts administer the Wetlands Protection Act, which, with the Forest Cutting Practices Act, covers logging in wetlands.

Finally, three special tax laws help landowners with local property taxes in Massachusetts:

Chapter 61 reduces annual taxes on woodlands by 95 percent and imposes a severance tax on products cut under an approved timber-management plan.

Chapter 61A gives relief to farmland and associated woodlots on *bona fide* active farms.

Chapter 61B grants some tax reduction for open land devoted to recreation.

It is also possible to get reduced property, income, and inheritance taxes by granting a conservation easement on forest or other open land to the town or some other acceptable conservation organization. There are also some federal income-tax advantages for forest returns.

•READ UP. One of the best references I have found is the *Manual for Owners and Managers of Small Forest Lands*, prepared by Garry van Wart for the Trustees of Reservations (224 Adams Street, Milton, MA 02186; telephone [617] 698-2066). This 113-page volume is available for $2.50 plus $1.35 for postage and handling. It gives more than 200 useful documents, classified according to eight subjects of special interest to landowners, in its list of references.

Rockwell R. Stephens has written an entertaining and informative book on the joys and woes of handling a woodlot. Entitled *One Man's Forest: Managing Your Woodlot for Pleasure & Profit*, it was published in 1974 by the Stephen Greene Press (Brattleboro, VT 05301) and is still in print in paperback for $6.95.

The New York Society of American Foresters has published a set of guidelines for the safe and efficient harvesting of woodlots. Entitled *The Timber Harvest Guidelines*, they are available free of charge from the Society (c/o Richard Schwab, 200 New Maintenance Building, College of Environmental Science and Forestry, State University of New York, Syracuse 13210).

•SEEK ADVICE. There are a number of places where landowners can get sound advice on managing a woodlot. In Massachusetts, each county has a service forester, whose services are free of charge. To get in touch with yours, consult the "Directory" beginning on page 11 of this issue of *Arnoldia*. The service forester, who can get federal cost-sharing assistance for you to undertake certain projects in your woodlot, is also the person to call if you want to locate a consultant or invest in tree management.

In addition, there is an extension forester at most state land-grant universities (see the "Directory"). He (or she) is paid to use the resources of academia to help solve technical forestry problems and has a number of very helpful, free publications about forestry. You also can get free advice from the Cooperative Extension Service office, which usually is located in the county seat. The Soil Conservation Service's district office for your locality is also a source of technical help with water-, soil-, and land-management problems. Private conservation organizations such as the Audubon Society, the Massachusetts Land League, and the Conservation Law Foundation are good sources of information for woodlot owners in Massachusetts. Similar organizations exist in virtually every state.

— **E.G.**

WHERE TO GO FOR ADVICE

A DIRECTORY OF INFORMATION SOURCES ON FORESTRY MANAGEMENT

In the United States and Canada, federal, state or provincial, and private agencies, as well as state universities, provide a wide variety of sound information on the management of small woodlands. In some cases the information is available at no charge, in others there is a fee. A brief directory to some of the key information sources follows. Addresses and, whenever possible, telephone numbers are indicated.

NATIONAL

Federal Government (United States)
Forest Service
Department of Agriculture
Post Office Box 2417
Washington, DC 20013
(202) 447-3957

Federal Government (Canada)
Forestry Service
Environment Canada
Ottawa, Ontario K1A 1G5
(819) 994-1879

Petawawa National Forestry Institute
Chalk River, Ontario K0J 1J0
(613) 995-7010

REGIONAL

Federal Government (United States)
Northeastern Area Director
U.S. Forest Service
State and Private Forestry
370 Reed Road
Broomall, PA 19008
(215) 461-3125

NEW ENGLAND

The New England Forestry Foundation (85 Newbury Street, Boston, MA 02116) retains consulting woodland managers who will (for a fee) draw up a management plan according to a woodland owner's wishes. Write the Foundation's Head Forester, or call (617) 437-1441.

Massachusetts
(Area Codes 617 and 413)

State Government

In Massachusetts, the Bureau of Forest Development has divided the state into five regions, each with its Regional Supervisor. In addition to the Bureau's Main Office in Boston, there is an office in Lancaster.

Boston Office (19th Floor, 100 Cambridge Street, Boston 02202)

State Forester	(617) 727-3163
Chief Forester	(617) 727-3184

Lancaster Office (Post Office Box 173, Lancaster 01523)

Forester	(617) 368-1780

Forestry Regions

Region I, Southeastern Massachusetts (Myles Standish State Forest, Box 66, South Carver 02366)

Supervisor	(617) 866-2580

Region II, Northeastern Massachusetts (Carlisle Regional Headquarters, 817 Lowell Road, Carlisle 01741)

Supervisor	(617) 369-3351

Region III, Worcester County (Box 155, Clinton 01510)

Supervisor	(617) 368-0126

Region IV, Connecticut Valley (Box 484, Amherst 01004)

Supervisor	(413) 549-1461

Hamden County (Hampton Ponds State Park, Route 202, Box 537A, Westfield 01085)

Forester	(413) 532-3985

Region V, Berkshire County (Post Office Box 1433, 740 South Street, Pittsfield 01202)

Supervisor	(413) 442-8928

State Bookstore

The State Bookstore sells a booklet containing all of the regulations of the Division of Forests and Parks. To order the booklet, request Document 304 CMR 1.00–5.00 and enclose a check for $4.05 ($3.00 plus $1.05 for postage) made out to "Commonwealth of Massachusetts." The bookstore's address is:

State Bookstore
Room 116
State House
Boston, MA 02133

Its telephone number is (617) 727-2834.

Extension Service
Extension Forester
Department of Forestry and Wildlife Management

Holdsworth Hall
University of Massachusetts
Amherst 01003
(413) 545-2665

State University
Chairman, Department of Forestry and Wildlife Management
Holdsworth Hall
University of Massachusetts
(413) 545-2665

The Other New England States

Connecticut
(Area Code 203)

State Government
State Forester
State Office Building
165 Capitol Avenue
Hartford 06106
566-5348

Private
Connecticut Forest and Park Association, Inc.
1010 Main Street
Post Office Box 8537
East Hartford 06108-8537
289-3637

Extension Service
Extension Forester
Box U-87
University of Connecticut
Storrs 06268

Extension Forester
Extension Center
Brooklyn 06234

Maine
(Area Code 207)

State Government
Maine Forest Service
Station 22
State House
Augusta 04333
289-2791

Land Use Regulation Commission [for woodlands within unorganized towns and plantations]
Department of Conservation
Station 22
State House
289-2631 [Toll-free in Maine: 1-800-452-8711]

Private
Small Woodland Owners Association of Maine, Inc.
RFD 1, Box 420A
Pittsfield 04967

Several paper companies (for example, Boise Cascade in Rumford, Georgia Pacific in Woodland, International Paper in Augusta, Robbins Lumber in Searsmont, St. Regis in Bucksport, Scott Paper Company in Fairfield, and S. D. Warren in Westbrook) offer woodland-management advice to private landowners. In most cases there is no charge for this service, though some companies ask for first-refusal rights on the timber.

Extension Service
Extension Forester
107 Nutting Hall
University of Maine
Orono 04469
581-2892

State University
Director, School of Forest Resources
206 Nutting Hall
University of Maine
581-2844

New Hampshire
(Area Code 603)

State Government
Director, Division of Forests and Lands
Department of Resources and Economic Development
Post Office Box 856
105 Loudon Road
Concord 03301
271-2214

Chairman, Department of Forest Resources
215 James Hall
University of New Hampshire
Durham 03824
862-1020

Private
Society for the Preservation of New Hampshire Forests
54 Portsmouth Street
Concord 03301
224-9945

Extension Service

Extension Forester
110 Pettee Hall
University of New Hampshire
862-1029

County Forest Management Supervisor
111 Pettee Hall
University of New Hampshire
862-1029

Rhode Island
(Area Code 401)

State Government

Chief, Division of Forest Environment
Route 101
RFD 2, Box 851
North Scituate 02857
647-3367

Extension Service

Director of Cooperative Extension Service
University of Rhode Island
Kingston 02881
792-2474

Regional Offices (9:00 A.M. to 2:00 P.M., weekdays):

Southern Rhode Island	539-2004
Providence area	272-1132
Jamestown area	423-1322

State University

Chairman, Department of Natural Resource Science
201B Woodward Hall
University of Rhode Island
792-2370

Vermont
(Area Code 802)

State Government

Director of Forests
Agency of Environmental Conservation
State Office Building
Montpelier 05602
828-3375

Extension Service

Extension Forester
Room 345
The Aiken Center
University of Vermont
Burlington 05405-0088
656-3258

State University

Department of Forestry
School of Natural Resources
Room 313
The Aiken Center
University of Vermont
656-2620

OUTSIDE NEW ENGLAND

New York
(Area Codes 315, 518, and 607)

State Government

Director, Division of Lands and Forests
Department of Environmental Conservation
Room 404
50 Wolf Road
Albany 12233-0001
(518) 457-2475

Bureaus of the Division of Lands and Forests (all at 50 Wolf Road, Albany 12233-0001):

Forest Management Bureau
Room 406
(518) 457-7370

Real Property Services Bureau
Room 116
(518) 457-7670

Forest Protection and Fire Management Bureau
Room 408
(518) 457-5740

Private

Secretary, New York Forest Owners Association, Inc.
Skyhigh Road, RD 2
Tully 13159
(315) 696-8002

Extension Service

Forest Resources and Land Use
State Cooperative Extension
Department of Natural Resources
122A Fernow Hall
Cornell University
Ithaca 14853-0188
(607) 256-7703

State University

School of Forestry
107 Marshall Hall
State University of New York

College of Environmental Science and Forestry at
Syracuse University
Syracuse 13210

ELSEWHERE

Contact the department of natural resources or environment in your state or provincial capital for the addresses and telephone numbers of your state's or province's foresters. In the United States, most extension foresters are stationed at and affiliated with state land-grant universities.

An excellent guide to state, provincial, and federal agencies and private organizations in both countries is the National Wildlife Federation's *Conservation Directory,* which is issued in a new edition at the start of each year. The 1985 edition is available from the Federation (1412 16th Street NW, Washington, DC 20036) for $15.00 plus $1.55 for shipping. When ordering, request Order Number 79552. Many libraries subscribe to the *Directory.*

RECOGNIZING AND TREATING AIR POLLUTION DAMAGE TO FAMILIAR CULTIVATED PLANTS: A CONFERENCE

JAMAICA PLAIN, MASSACHUSETTS
FRIDAY, SEPTEMBER 6, AND SATURDAY, SEPTEMBER 7, 1985

Conference on Phytotoxic Air Pollutants Will Unravel Technical Complexities and Develop Practical Solutions for the Nonspecialist

Cultivated plants suffer from pests of many kinds — animal, fungal, and bacterial. In most cases a culprit is easily pinpointed through routine experiments or even simple observation, and linked to the damage it wreaks. The cause-and-effect relationships between pests and symptoms are well worked out, and there is consensus among the experts. Even the effects of extreme heat, extreme cold, drought, windiness, and similar nonbiological agents are scientifically well understood. But when it comes to damage to plants caused (or suspected of being caused) by air pollutants, knowledge is sparse and tenuous at best; more often than not, the experts disagree about causes and symptoms—if they state any opinion at all. Reliable knowledge comes only through slow and painstaking scientific experimentation.

Fortunately, careful experimentation and observation have begun to yield insights into the complex relationships and interactions among the air pollutants (ozone, sulfur dioxide, nitrogen oxides, and so forth) that harm cultivated plants. Symptoms manifested by particular species and varieties have begun to be identified. Armed with the new understanding that has resulted from the scientific work, horticulturists and other plant scientists often are now able to devise solutions to counteract the effects of pollution.

Some plant scientists have opted to develop pollution-resistant strains, for example, while others implement measures for mitigating the effects of pollutants — amending soils with materials that counteract some of the effects of the pollutants, or prescribing new cultivation techniques. But to select a resistant strain or prescribe mitigating measures, one first must know which pollutant or combination of pollutants is responsible for the damage in question; this, in turn, requires an ability to identify the symptoms and damage characteristically caused by each particular pollutant or group of pollutants in individual species and varieties of plants. It is to foster this first, essential step among both professionals and advanced amateurs that *Arnoldia* magazine will sponsor "Recognizing and Treating Air Pollution Damage to Familiar Cultivated Plants: A Conference" on September 6 and 7, 1985.

The Conference will meet for two days in Jamaica Plain, Massachusetts. Indoor sessions will be held both days in the Massachusetts State Laboratory Institute building adjacent to the Arboretum; outdoor sessions will take place in the Arboretum itself.

> A 113-year-old botanical garden devoted to the woody plants of the North Temperate Zone, the Arnold Arboretum is a separately endowed institution within Harvard University and, at the same time, a component of the city of Boston's public-park system. It is an international center for research and instruction, presenting scientists and students with an exceptional opportunity to study the biology of trees and other woody plants. Its principal living collection of 6,192 taxa of trees and shrubs occupies a 265-acre site in the Jamaica Plain section of Boston. The best-documented collection of its kind in the world, it currently numbers in excess of 14,000 specimens. Records of the origin of each specimen and notations of observations by the staff increase the collection's value for research and education. Each plant is labelled with its name, accession number, and origin. Few locations in the world provide such a diverse array of plants. Participants in the Conference will examine some of the specimens in the living collections for identifiable air-pollution damage, under the guidance of the Conference's instructors.

A particularly extreme example of air-pollution damage to the leaves of a European linden growing two blocks from the White House in Washington, D.C. Photograph by Orie L. Loucks.

Format of the Conference

The Conference will be conducted as both a typical course of instruction and a participatory workshop, with the instructors serving as workshop leaders and the participants playing an active role in devising methods for ameliorating the effects of the pollutants. Instructors will present overviews of the current state of knowledge about phytotoxic air pollutants, concentrating on visible symptoms and the physiological mechanisms through which the pollutants affect individual species and varieties of plants, and will guide the participants in detailed on-site examination of typical symptoms on trees and shrubs in the Arboretum's living collections. The participants, who will consist of botanists, horticulturists, and other individuals knowledgeable in the plant sciences or immediately dependent for their livelihoods on plants, will join in on-the-spot discussions aimed at identifying practical measures for counteracting the observed effects. The emphasis will be placed on routine horticultural techniques whenever practicable, but innovative or unusual techniques will be sought whenever necessary.

The Conference will be very strongly geared to the special needs of nursery owners and other plantspeople, although nonprofessionals will be welcomed, of course. Participants will be urged to photograph specimens identified by the instructors as displaying characteristic symptoms of air-pollution damage. (Ideally, it should be possible in some cases to extrapolate the results of research to plants related to those used in the research.) Through this process of interaction between instructors and participants, a file of authenticated photographs will be made available. The resulting stockpile of photographs will serve as a source of illustrations for the Conference's proceedings, which will be published early in 1986 as a special seventy-fifth anniversary issue of *Arnoldia*. To be organized as a practical and

Air-pollution injury to the leaves of a magnolia growing near the White House in Washington, D. C. Photograph by Orie L. Loucks.

convenient field-identification manual, the proceedings volume should emerge as a standard ready-reference on phytotoxic air pollutants. Each participant in the Conference will automatically receive a copy of the special issue upon its publication.

Instructors

Instructors for the Conference will include horticulturists, botanists, and plant pathologists who have specialized in research on the effects of air pollution on economically important species of plants, including familiar ornamentals and other cultivated plants. One of the instructors, John H. Alexander III of the Arboretum staff, has participated in inter-institutional research projects on leaf-roll necrosis in lilacs, a disorder that is believed to be caused by ozone. Drs. William J. Manning of the University of Massachusetts at Amherst and William A. Feder of that University's Suburban Experiment Station in Waltham—the other principal participants in the project—will also serve as Conference instructors. Both have worked on phytotoxic air pollutants for many years. A plant pathologist, Dr. Manning specializes in the interaction between air pollutants and the biological agents of plant diseases, especially diseases of economic plants. Dr. Feder is also a plant pathologist; for many years he has led air-pollution research projects at the University of Massachusetts.

Dr. Orie L. Loucks has supervised numerous major research projects on the ecology of forests in the United States and Canada. He will contribute insights gained from three decades of intensive work. The director of Holcomb Research Institute, an institution that specializes in environmental research, Dr. Loucks currently is studying the effects of air pollution on forest trees and crop plants in the Midwest, especially the Ohio River valley.

A lilac seedling exposed to ozone in experiments done to determine the role ozone plays in causing leaf-roll necrosis. Photograph by John H. Alexander III.

Dr. David F. Karnosky of Michigan Technological University, a forest geneticist whose work deals with the variability in air-pollution tolerance of trees, currently is engaged in developing urban-hardy trees for use in heavily polluted areas. He was formerly on the staff of the Cary Arboretum of the New York Botanical Garden. Additional instructors will be engaged in the near future.

How to Register

The fee for the Conference is $130 or—for members of the Friends of the Arnold Arboretum, individual subscribers to *Arnoldia*, and members of the Massachusetts Horticultural Society—$90. Nonmembers and nonsubscribers who join or subscribe when they register for the Conference will quality for the lower fee.

The deadine for registration is June 14, 1985. A registration form accompanies this announcement. Please address inquiries to "Conference, The Arnold Arboretum, The Arborway, Jamaica Plan, MA 02130," or telephone (617) 524-1718.

Selected Background Readings

Björkman, Erik. The effect of fertilization on sulphur dioxide damage to conifers in industrial and built-up areas. *Studia Forestalia Suecica* No. 78. Stockholm: Royal College of Forestry, 1970. 48 pages.

Davis, Donald S., and Raymond G. Wilhour. *Susceptibility of Woody Plants to Sulfur Dioxide and Photochemical Oxidants: A Literature Review.* Ecological Research Series EPA-600/3-76-102. Corvallis, Oregon: U.S. Environmental Protection Agency, 1976. 72 pages.

Dochinger, Leon S., and Thomas A. Seliga, editors. *Proceedings of the First International Symposium on Acid Precipitation and the Forest Ecosystem, Columbus, Ohio, 1975.* General Technical Report NE-23. Upper Darby, Pennsylvania: Northeastern Forest Experiment Station, Forest Service, 1976. 1074 pages.

European Congress on the Influence of Air Pollution on Plants and Animals, First, Wageningen, 1968. *Air Pollution.* Wageningen: Centre for Agricultural Publishing and Documentation, 1969. 415 pages.

Jacobson, Jay S., and A. C. Hill, editors. *Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas.* Informative Report No. 1. Pittsburgh: Air Pollution Control Association, 1970. 108 pages.

Kender, W. J., and N. J. Shaulis. Vineyard management practices influencing oxidant injury in 'Concord' grapevines. *Journal of the American Society of Horticultural Science*, Vol. 101, No. 2, pages 129–132 (1976).

Lacasse, Norman L., and M. Treshow, editors. *Diagnosing Vegetation Injury Caused by Air Pollution.* Ecological Research Series EPA-450/3-78-005. Research Triangle Park, North Carolina: U.S. Environmental Protection Agency, 1978. 299 pages.

Malhotra, S. S., and R. A. Blauel. *Diagnosis of Air Pollutant and Natural Stress Symptoms on Forest Vegetation in Western Canada.* Information Report NOR-X-228. Edmonton, Alberta: Northern Forest Research Centre, Canadian Forestry Service, 1980. 84 pages.

Musselman, R. C., and R. E. Melious. Sensitivity of grape cultivars to ambient ozone. *HortScience*, Vol. 19, No. 5, pages 657–659 (1984).

Oliver, F. W. On the effects of urban fog upon cultivated plants. *Journal of the Royal Horticultural Society*, Vol. 13, No. 1, pages 139–151 (1891) and Vol. 16, No. 1, pages 1–59 (1893).

Ormond, D. P. *Pollution in Horticulture.* Fundamental Aspects of Pollution Control and Environmental Science 4. Amsterdam, Oxford, and New York: Elsevier Scientific Publishing Company, 1978. 260 pages.

Plochmann, Richard. Air pollution and the dying forests of Europe. *American Forests*, Vol. 90, No. 6, pages 17–21, 56 (June 1984).

Smith, G. C., and E. G. Brennan. Response of honeylocust cultivars to air pollution stress in an urban environment. *Journal of Arboriculture*, Vol. 10, No. 11, pages 289–293 (November 1984).

Usher, Roland W., and Wayne T. Williams. Air pollution toxicity to Eastern White Pine in Indiana and Wisconsin. *Plant Disease*, Vol. 66, No. 3, pages 199–204 (March 1982).

The Layered Look

Peter Del Tredici

The humble bunchberry yields startling insights into tree architecture

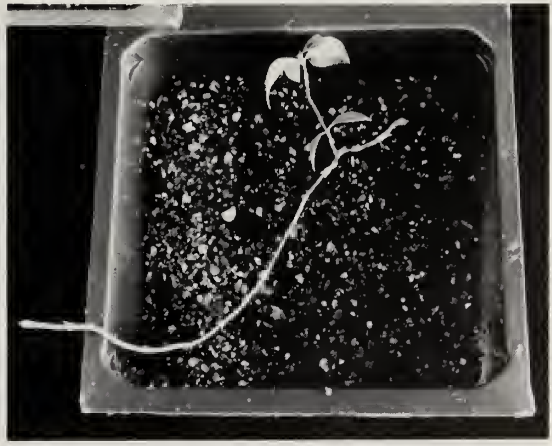
I shall never forget a walk in the woods I once took at the Harvard Forest in Petersham, Massachusetts, with Francis Hallé, the French botanist who pioneered the study of tree architecture. It was April 1975, and the forest floor was alive with wildflowers. Among them was *Cornus canadensis*, the bunchberry, which was just coming out. Dr. Hallé took one look at the little plant and said that it was like a flowering dogwood (*C. florida*) lying on its side, growing horizontally through the litter rather than vertically. It was a fanciful statement, containing more poetry than botany, I thought, yet something about it rang true.

After years of thinking about Dr. Hallé's comment in only the vaguest of terms, I recently had the opportunity to look into it more critically when a group of bunchberry seeds I had collected near Mount Katahdin in Maine germinated in the Dana Greenhouses of the Arnold Arboretum (see the table, page 21). The little seedlings grew amazingly fast and after just a single season's growth were producing numerous underground stems. These rhizomes, as such underground stems are called, grew out either from the axils of the seed leaves — the cotyledons — or from the axils of the first few true leaves. Seedlings that did not produce rhizomes set large buds which grew out as rhizomes the following spring.

The fact that these bunchberry seedlings produced rhizomes in their first season came as a surprise to me because it is exactly the reverse of the behavior exhibited by most tree seedlings, which build a strong vertical stem by preventing the buds lower down on the trunk from growing out during their first year. Clearly, *C. canadensis* lacks the strict apical control that most woody plants exhibit.

In the most well-developed year-old bunchberry seedlings, the tips of the rhizomes had turned up and formed new above-ground shoots, each with a characteristic whorl of leaves. At some variable point below this region of upturning, one or more new buds had formed in the axils of the rhizomes' bud scales; they were destined to continue horizontal growth through the forest litter when they grow out the following spring. What at first glance might appear to be a population of separate bunchberry plants, then, usually turns out to be a single individual.

While none of the bunchberry seedlings I grew reached flowering age, I found that mature



A *Cornus canadensis* seedling in its first season, showing rhizomes growing from the axils on the cotyledons. Photograph by Peter Del Tredici.

Germination of Bunchberry Seeds*

Treatment	*Germination %*
sow in greenhouse	0
3 months cold stratification	21
sow outdoors	4
1½ hr. sulfuric acid + 3 months cold stratification	18
1½ hr. sulfuric acid + sow outdoors	74

*The germination of *Cornus canadensis* seed collected wild on the Penobscot River, near Mount Katahdin, Maine. Seeds (100 per treatment) were sown on September 14, 1982. Seedlings were counted on December 13, 1983. The soak in concentrated sulfuric acid was recommended by C. S. Schopmeyer in 1974.

specimens cultivated at the Arboretum usually, but not always, flowered on the upturned tips of these rhizomes, while buds closer to the base of the rhizome grew out, producing new rhizomes that would turn upward and flower the next spring. The plant thus produces a branch system built up by the activities of several different buds growing out in relays — each of which continues the line of growth in the horizontal direction after the previous bud turns up to produce a flower.

Before one can answer the question of whether this growth habit of *C. canadensis* is just a horizontal version of that of *C. florida*, as Dr. Hallé initially suggested, one needs to have a clear conception of how the latter species grows. First, flowering dogwood has a "layered" look in the arrangement of its branches, which Hal Borland

A *Cornus canadensis* seedling showing a well-developed cotyledonary crown. The arrow points to a relay bud that will grow out the following season. Photograph by Peter Del Tredici.

The earliest known illustration of *Cornus canadensis*, from the 1672 edition of *New England's Rarities, discovered*, with the following caption:

> This plant I take for a variegated Herb *Paris, True Love*, or *One Berry*, or rather *One Flower*, which is milk white, and made up with four Leaves, with many black threads in the middle, upon every thread grows a Berry (when the Leaves of the Flower are fallen) as big as a white pease, of a light red colour when they are ripe, and clustering together in a round form as big as a Pullets Egg, which at a distance shews but as one Berry, very pleasant in taste, and not unwholesome. . . .

describes as "horizontal limbs that reach skyward at their tips and form a fine lace pattern." Among deciduous temperate zone trees, such layering is unusual. It occurs in the dogwood because the shoot that builds the central trunk is physiologically distinct from the shoots that build the lateral branches. The trunk is produced by the activity of a single meristem that grows vertically year after year, while the lateral branches are produced by meristems growing horizontally in "relays." These relays originate in buds below the shoots that turned upward to produce flowers.

In reality, the distinction between the behavior of the terminal and the lateral shoots of flowering dogwood is not as clear-cut as I have described. In particular, the terminal shoot often seems to lose its vigor for no apparent reason and is replaced by one of the laterals. This usually occurs in the spring, when the young branches are beginning to grow out.

The growth habit of the bunchberry, of course, is entirely different from that of the flowering

Cornus florida winter silhouette. Drawing by Olga A. Smith, from *Tree Flowers of Forest, Park, and Street*, by Walter E. Rogers; courtesy of Dover Publications, Inc.

dogwood. Yet a curious similarity exists: the bunchberry plant resembles a lateral branch of flowering dogwood growing independent of a trunk. Dr. Hallé later discussed this in his book, *Tropical Trees and Forests*, written with R. A. A. Oldeman and P. B. Tomlinson. In it, he states that the architecture of herbs is derived from that of trees by a process he calls "fragmentation":

> In *Cornus canadensis* the creeping, somewhat woody axis may be equated with one branch of a tree ancestor. The superficial similarity is enhanced by the development of foliage leaves in distinct rosettes along the horizontal axis in both forms. In such examples, if this interpretation is correct, there should be some eivdence of the orthotropic [vertical] trunk in the epicotyledonary axis.

Having followed up Dr. Hallé's speculation with some solid observation of my own, I can now say that the only remnant of a trunk in *C. canadensis* is the vertical tip of the seedling shoot, which reaches a height of no more than two or three centimeters before the basal rhizomes grow out and compete with it. The fact that the rhizomes take root as they grow through the soil not only eliminates the need for a central trunk to distribute nutrients, but also the need for any centralized control over their growth pattern.

At this time, no one knows why bunchberry lacks apical control. There are two possibilities. The terminal bud may not produce the growth-inhibiting hormones that would keep the rhizomes from growing, or the rhizomes may be insensitive to any inhibitory hormones the terminal bud might be producing. Regardless of which is true, apical control is at the heart of the differences in growth habit between *Cornus florida* and *Cornus canadensis*. Clearly, Dr. Hallé was right when he described the bunchberry as a flowering dogwood without a trunk.

Sources

Borland, H., and L. Line. *A Countryman's Woods*. New York: Alfred A. Knopf, 1983.

Chapagnat, P. 1976. Formation of the trunk in woody plants. In *Tropical Trees as Living Systems*, edited by P. B. Tomlinson and M. H. Zimmermann. Cambridge: Cambridge University Press, 1976.

Ferguson, I. K. The Cornaceae in the Southeastern United States. *Journal of the Arnold Arboretum*, 47(2): 106-16 (1966).

Hallé, F., R. A. A. Oldeman, and P. B. Tomlinson. *Tropical Trees and Forests*. Berlin, Heidelberg, New York: SPringer-Verlag 1978.

Josselyn, J. *New England's Rarities*. 1672. Reprint. Boston: William Veazie, 1865.

Ramaroson-Ramparany, L. "Contribution à l'étude architecturale de quelques ligneuses des régions tempérées." Ph.D. thesis, Académie de Montpellier, France, 1978.

Rogers, W. E. *Tree Flowers of Forest, Park and Street*. Appleton, Wisconsin: W. E. Rogers, 1935.

Schopmeyer, C. S., ed. *Seeds of Woody Plants in the United States*. Agriculture Handbook No. 450. Washington, D.C.: Forest Service, U.S. Department of Agriculture, 1974.

Peter Del Tredici is assistant plant propagator at the Arnold Arboretum and associate editor of *Arnoldia*.

The 'Okame' Cherry

Paul W. Meyer
Rick Lewandowski

This early-flowering hybrid is reliably hardy to Zone 5

Of the many cultivated varieties of flowering cherry growing at the Morris Arboretum of the University of Pennsylvania, the most popular with staff and visitors alike is *Prunus ×incam* 'Okame'. Its bright fuchsine-pink flowers (Horticultural Colour Chart 627/2) are among the earliest spring blossoms to appear. They never fail to attract attention. In Philadelphia, the blossoms open as early as March 28th and as late as April 13th, depending on the weather. Even before the blossoms open, the deep maroon flower buds are showy, while the red calyx and stamens persist for a week after the petals drop. Thus, spring color lasts for up to three weeks.

'Okame' cherry has a small, upright crown maturing at 25 feet. Its small stature and fine leaf texture make it particularly adaptable to small gardens. In the autumn its foliage becomes bright shades of orange and yellow.

'Okame' was produced in England early this century by Captain Collingwood Ingram, a famed cherry collector and hybridizer. Ingram had been impressed with the deep rose flowers of *Prunus campanulata* but was frustrated by its lack of winter hardiness. Using *P. campanulata* as the pollen parent, he crossed it with *P. incisa*, a species noted for its profusion of flowers and cold hardiness. 'Okame' was selected as a superior seedling from this cross. In 1952, it received the Award of Garden Merit from the Royal Horticultural Society.

Dr. Henry Skinner obtained scion wood from Captain Ingram and brought it to the Morris Arboretum in 1946. Though distributed to other botanical institutions, 'Okame' remains rare in the nursery trade. Conard Pyle Nursery and J. Frank Schmidt Nursery are large wholesale companies that have recently begun to produce it. In addition, Weston Nurseries in Hopkinton, Massachusetts, is growing 'Okame', and Wayside Gardens will offer it to mail-order customers beginning in the spring of 1985.

Research has shown that 'Okame' cherry roots easily from softwood cuttings and is well adapted to both field and container production. At the Morris Arboretum, six-inch cuttings are taken from mid- to late June. These are treated with Hormoroot A (1,000 parts per million of indolebutyric acid and Thiram), and 95 percent of the cuttings are well rooted within four weeks. Terminal cuttings yield plants with the best upright form; lateral cuttings require pruning to form a strong leader.

As a young plant, 'Okame' cherry grows rapidly and often begins flowering immediately. It is fully hardy in Philadelphia, and the expanding flower buds withstand late spring frosts. It thrives at the Arnold Arboretum, and a specimen observed in Cincinnati for the past six years has been unaffected by the winters. Thus far, 'Okame' cherry has been reliably hardy to Zone 5.

In 1981 'Okame' received the Preliminary Commendation of the Pennsylvania Horticultural Society and is now being evaluated for the J. Franklin Styer Award for Exceptional Garden Merit.

Sources

Bean, W. J. *Trees and Shrubs Hardy in the British Isles,* eighth edition. Four volumes. London: John Murray, 1976. (The 'Okame' cherry is described in Volume 3, page 376.)

Fletcher, H. R. Award of Garden Merit—LXXXVII. *Journal of the Royal Horticultural Society,* Vol. 79, No. 3, pages 127–133 (1954). ('Okame' is discussed on pages 130 and 131.)

Paul W. Meyer is Assistant Director of Horticulture and Rick Lewandowski Assistant Curator for Propagation, at the Morris Arboretum of the University of Pennsylvania.

COLLECTOR'S NOTEBOOK

The Appeal of Phloxes

Richard E. Weaver, Jr.

Phlox is one of America's notable contributions to horticulture. Its 60 or so species are totally North American in distribution, save for a single Siberian species. The appeal of phloxes to gardeners is understandable, because they are both beautiful and serviceable plants. The species vary greatly in height and habit, some being delicate annuals, some prostrate alpine subshrubs, others upright herbaceous perennials five feet tall. And they grow under a variety of soil and light conditions. In fact, there is a phlox for nearly every garden situation.

The flowers of most eastern American species are what is often referred to as "phlox-purple." This rosy-purple color is unattractive to many people. But fortunately, most species are quite variable in the wild, and the most attractively colored forms have been selected and brought into cultivation. And breeding by horticulturists and other plant scientists has further expanded the color range, so many species are now represented in cultivation by white, pink, nearly red, and bluish variants.

Most alpine phloxes are somewhat difficult to cultivate and are grown mostly by collectors and specialty gardeners. Others are very easy and therefore almost ubiquitous in cultivation. *Phlox subulata,* the "moss pink" or

Phlox glaberrima. Photograph by Albert W. Bussewitz.

A cluster of *Phlox carolina.* Photograph by the author.

'Miss Lingard'. Photograph by Gary L. Koller.

An inflorescence of *Phlox carolina.* Photograph by the author.

"thrift" of the Southeast, turns banks everywhere a mass of pink, purple, or white in the early spring. A perennial border, no matter how small or simple, would not be complete without several cultivars of the summer phlox (*P. paniculata*). And the blue phlox (*P. divaricata*) and the creeping phlox (*P. stolonifera*) are standard components of the wildflower garden.

But other, equally useful species are relatively rare in cultivation. I would like to concentrate here on several primarily Southeastern species that I have come to know well since moving to North Carolina. *Phlox amoena* is one of our commonest roadside wildflowers during May, being so abundant in some areas that it appears to have been planted. It is a low plant with decumbent stems and upright, compact inflorescences of ¾-inch flowers. The flowers are normally a bright phlox-purple, but we have selected the following forms: a large-flowered white, a small-flowered white, a blush pink, a pale blue-lavender with a darker star in the center, and a deep rose with a purple eye. I find the normal wild plant very attractive, but for those who do not like its color the abovementioned forms will soon be available. *Phlox amoena* is easy to cultivate, thriving in a sunny, well-drained situation. It is a good plant for the rockery, the front of the border, or those odd, small spots in the garden where a plant of low stature is needed.

The remaining species are all closely related: they are similar to the summer phlox in many ways but bloom earlier than it does and have narrower leaves that are highly resistant to the powdery mildew, which can so badly disfigure *P. paniculata.* The most distinctive of these species is *P. ovata,* the mountain phlox, native to rich forests and forest margins in the southern Appalachian region. It is a stoloniferous species, producing many sterile shoots and relatively few flowering shoots; these latter seldom exceed 15 inches in height. To me it is among the most beautiful of the phloxes, with its large flowers, pinker than in most species, appearing in late May and early June. Because it is stoloniferous and not a profuse bloomer, *P. ovata* is a plant for the wildflower garden rather than the perennial border.

Phlox carolina and *P. glaberrima* are similar and often confused. The former tends to be of taller stature, however—three feet tall versus two feet — and often grows in shadier situations. Both have long blooming seasons, starting in late June and extending into August, and overlap the summer phlox for some of that period. The flowers are typically phlox-purple, but those of *P. carolina* are extremely variable, and we have selected some beautiful bicolored forms. Unfortunately, we have not yet found a white-flowered form of either species, but we will continue our search. Both species are excellent border plants, and *P. carolina* is also good in the shady garden.

Phlox maculata is one of the most outstanding species of *Phlox* from a horticultural viewpoint. It differs from the preceding three species in having purple-speckled stems and narrow, cylindrical inflorescences. The wild plant is quite gardenworthy, but it is certainly overshadowed by three spectacular cultivars. 'Miss Lingard' is the finest of these, is, in fact, one of the very best of all border plants. Plants stand tall and stately (about 50 inches in our garden) and have not needed staking even with last summer's torrential rains. The flowers are pure white and borne in an inflorescence about a foot tall. The plants were in full bloom by early June and still blooming in early August; there was admittedly a hiatus of about two weeks in mid-July after the first, spent inflorescences were cut off. 'Reine du Jour' blooms when 'Miss Lingard' does, but grows only to about 30 inches tall. Its flowers are pure white with a purple eye. 'Rosalinde' is the latest-blooming and tallest of the three cultivars. Our plants were in full bloom in late June, and they stood 55 inches tall. The flowers are on the pink side of phlox-purple and borne in magnificent 12- to 15-inch inflorescences. I have seen reference to 'Alpha', a clear-pink-flowered cultivar, but unfortunately have not yet been able to find a plant.

It should be noted that there is some confusion as to the species to which the abovementioned cultivars belong. The authors of *Hortus III* consider at least 'Miss Lingard' to be a cultivar of *P. carolina.* Some perhaps arose as interspecific hybrids. But with their speckled stems and cylindrical inflorescences, they are certainly more like *P. maculata* than any other species. In any event, they are first-rate garden plants, thriving in full sun or partial shade. Our experience has shown that they are taller and more vigorous if grown in moist soil. They seldom if ever need staking the way cultivars of the summer phlox often do.

All of the above species are available from dealers in wildflowers. Most of the cultivars of *P. maculata* ('Miss Lingard' most reliably) are occasionally listed by the standard perennial growers.

Richard E. Weaver, Jr., the former horticultural taxonomist at the Arnold Arboretum, now operates We-Du Nurseries in Marion, North Carolina.

BOOKS

Drawn from Nature: The Botanical Art of Joseph Prestele and His Sons, by Charles van Ravenswaay. Washington, D.C.: Smithsonian Institution Press, 1984. 357 pages, 95 colored plates. $45.00.

ANN HAYMOND ZWINGER

Drawn from Nature: The Botanical Art of Joseph Prestele and His Sons, is a magnificent publication from the Smithsonian Press. Large in format, with a scholarly introduction, and more than half of it dedicated to full-page color illustrations, the book epitomizes the interest in botanical illustration that has burgeoned in recent decades. When I first became interested in drawing plants twenty years ago, the only available book with any historical information was Wilfrid Blunt's *The Art of Botanical Illustration*, first published in 1950 as one of the British "New Naturalist" series. Although fairly well illustrated, the text was pedantic and scarcely deigned to mention any illustrators working in the United States.

Mr. van Ravenswaay's book is informative as well as lovely to look at, and gives technical as well as historical information. The book's arrangement furthers the reader's enjoyment by having a brief comment, information on provenance, and, often, interesting sidelights placed opposite each illustration. The appendixes make the book useful to the scholar, and its design, down to the endpapers, is both elegant and beautiful.

Charles van Ravenswaay is well-qualified to write on botanical illustration, being the director emeritus of the Henry Francis du Pont Winterthur Museum and Gardens; he discovered Prestele when he bought a portfolio of engravings of American trees, published by the Smithsonian in 1891. The quality of the work so attracted him that he set out to determine the illustrator. It was Joseph Prestele, one of the first in this country.

Mr. van Ravenswaay's biography of Prestele is well drawn and well researched. Prestele was born and grew up in Germany; at 16 he was already producing respectable work, although the coloring was heavy-handed and botanical details were glossed over or lacking. By the time he was 20, Prestele had been hired as staff artist for the Royal Botanical Garden in Munich. It was a productive and formative time, and his drawings took on an accuracy and perception that indicate solid training in botany. His illustrations of the common poisonous plants of Germany were known to Asa Gray. Of the four plates that Mr. van Ravenswaay has chosen from this rare book (*Die Wichtigsten Giftpflanzen Deutschlands*), *Conium maculatum*, spotted hemlock, is my favorite for the delicacy of its execution. Two stalks are portrayed in color; one shows the struc-

Conium maculatum, spotted hemlock, from the plate by Joseph Prestele in *Die Wichtigsten Giftpflanzen Deutschlands* (1843). The delicate, uncolored leaf appears as a scarcely visible, ghostlike presence on the righthand side of the plate.

ture of the stem, the other the upper stem with intricate flower and seed heads. One entire leaf is left uncolored; the dreamlike precision of the drawing unifies the two stalks, thus informs without cluttering.

Although raised a Catholic, Prestele became interested in a religious group called Inspirationalists, who settled first in upper New York State in the 1840s and later established the Amana Colonies in Iowa. Mr. van Ravenswaay discusses at some length how this constrictive communal life curtailed Prestele's artistic output.

In 1844, a year after he moved to New York with the community, the elders allowed Prestele to begin work on wildflower illustrations. Since he and his son Gottlieb couldn't identify many of the new plants, Prestele wrote to the premier botanist of the United States, Asa Gray, to whom he had an introduction. His letter appeared on Gray's desk in January 1845, just when Gray needed an engraver. Gray not only welcomed Prestele but introduced him to John Torrey. Both botanists used Prestele's services as an "engraver on stone," which involved using a technique that is not true engraving but which allows meticulously fine renderings.

Prestele was a capable and sensitive draftsman. In his work for Gray and Torrey, he often engraved from the drawings of Isaac Sprague, a protégé of Gray's who worked directly from plants in the botanic garden at Harvard. This collaboration resulted in the illustrations for Gray's *Chloris boreali-americana*, published in 1846. Prestele engraved, printed, and hand-colored the prints. Working with distant printers often caused him grief; about the plate of *Gaillardia amblyodon*, Prestele wrote to Gray: "In short, Dear Sir, I suffered a great deal on account of seeing that I was unable to do Things Well for you."

This project was never completed, as the over-energetic Gray was off on a new tack, an ambitious undertaking to publish drawings of a single species of each genus of plants of the United States. Prestele did 100 plates (for which he charged $2.50 each) for the first volume of *Genera florae americae.* Gray envisioned a ten-volume set, but only two volumes were ever printed.

Gray's next great project, suggested by Professor Joseph Henry at the Smithsonian, had a similar fate. *The Forest Trees of North America,* to be published by the Smithsonian, came to an "embarrassing halt" because it was too expensive and too ambitious; Gray and Henry evidently did not sufficiently understand the scope of the project. Prestele's work for Gray essentially terminated at that point, but he continued to work for Torrey, who was in charge of the botanical illustrations for the western surveys. Prestele did all of the engravings of plants for the Pacific Railroad Surveys, published between 1853 and 1856. He illustrated William H. Emory's *Report on the United States and Mexican Boundary,* as well as Charles Wilkes' *United States Exploring Expedition 1844–1874.* (An appendix gives a complete listing of the illustrations, although none of them are reproduced in this book.)

By the late 1840s Prestele was also rendering "nurserymen illustrations" that conveyed the delights of various fruits. Between 1854 and 1860 he made between 2,000 and 3,000 plates for the Mount Hope Nursery in Rochester, New York. Some of these are stunning in the virtuosity of their coloring and rendering of surface texture: the bloom on the 'Concord' grape, the sheen of 'White French Guigne' cherries and the pattern of their multiple stems, the blush on a ripe 'Late Crawford' peach, are monuments to the kind of fruit we used to have. The blemish on a 'Red Astrachan' apple provides the precise balance for the dark seeds set in the white flesh of a cross section. In these the design is charming, the botanical knowledge definitive, the coloring masterful.

As a means of describing plants to the public, this meticulous and time-consuming botanical illustration was becoming outdated by the end of Prestele's life. Of the three sons who followed his profession, only Gottlieb, who remained in the Amana Colony, produced any volume of work.

By the end of the nineteenth century color printing and, eventually, color photography were developed, providing inexpensive, mass-produced illustrations. But they also, in a sense, robbed our generation of the precisely noted and carefully rendered illustrations that illuminated the previous four centuries. Color photography can never focus on and render telling detail as effectively as a good drawing; nor can it include, in an aesthetically pleasing way, several morphological details on the same page. The monumental volumes on the flora of the United States, published by the New York Botanical Garden, illustrate this point: though extravagantly illustrated with photographs, even they resorted to drawings to show details.

In all the kinds of botanical illustration, one thing has remained constant: the love of plants. The most enduring quality is the illustrator's joy in the curve of leaf, the turn of petal, the celebration of growth. In almost any book of botanical illustrations one can find pleasure just in the looking. But that pleasure is multiplied considerably when the reproductions are elegantly presented on heavy coated paper, the colors true, and the text engaging.

Mr. van Ravenswaay's book is a labor of love. Like birders, people who love plants have a deep and abiding devotion to their subject. This book belongs in the library of anyone who enjoys botanical illustration enhanced by lively scholarly commentary and competent documentation.

Ann Haymond Zwinger is a well-known author and artist who specializes in natural history subjects. She is coauthor (with Beatrice E. Willard) of *Land Above the Trees: A Guide to American Alpine Tundra.*

A Field Guide to Poisonous Plants and Mushrooms of North America, by Charles Kingsley Levy and Richard B. Primack. Illustrated by L. L. Meszoly and M. H. Primack. Brattleboro, Vermont, and Lexington, Massachusetts: Stephen Greene Press, 1984. 178 pages. $9.95 (soft cover).

RICHARD EVANS SCHULTES

Here is a definite, workable field guide to toxic plants of North America. Most works on poisonous plants of this continent are either very old, extremely voluminous, highly technical, or oriented primarily towards the veterinarian's use. Pocket-sized, this book is easy to carry where one needs to know what plants to avoid. It is illustrated with simple line drawings for most of the species and excellent color photographs of the most frequently met species, and is writtten in an orderly, straightforward style.

The subject matter is organized into five parts dealing in turn with plants that cause dermatitis, hallucinogens, home and garden poisons, toxic wild plants, and poisonous mushrooms. The part on mushrooms is subdivided into deadly or potentially deadly species and species that stimulate the parasympathetic nervous system. A similar order of presentation is followed for each plant: a description; its distribution and habitat; toxins and symptoms; first aid and medical treatment. Historical or ethnobotanical information of general interest is frequently given. The introduction gives an overview of the scope of the problem of poisonous plants, as well as practical instructions for counteracting the effects of plant toxins.

This book has been written after careful and extensive consideration of the latest literature, constant consultation with the Boston Poison Center, and personal experience. One of its prime recommendations is its orientation towards human beings.

The authors, both professors at Boston University (one a zoologist, the other a botanist), have had wide experience in Africa, New Zealand, Australia, Chile, Costa Rica, and Borneo.

Trees of the Great Basin: A Natural History, by Ronald M. Lanner. Drawings by C. Rasmuss. Reno: University of Nevada Press, 1984. 217 pages. $19.50.

RICHARD EVANS SCHULTES

The author, an active field dendrologist of many years' experience, has travelled widely and written on trees of the Great Basin, the American

Southwest, and the Rocky Mountains. This, his second book on the region, describes 47 native species—23 gymnosperms and 24 angiosperms—and examines their place in local ecology, exploring the life histories of the trees and their relationships to animal life, including man, in the area. Growth habits and requirements, taxonomy, genetics, and, when pertinent, their economic importance are discussed in a leisurely, readable, almost conversational style that does not lower itself to the common denominator of newspaper or magazine popular appeal. The greatest single attraction of this book is its success in making available much information hitherto hidden in scientific or technical and difficult-to-obtain publications.

Each species considered is beautifully and simply illustrated with a clear line drawing and a superb color photograph. Several pages of derivations of botanical terms make the volume even more valuable to the nontechnical tree-lover. A list of 22 suggested readings is offered and a full index of common and scientific names is appended.

This is a delightful and useful book for the library of any scholar or amateur whose interests lie in this part of the American West.

Richard Evans Schultes is Director of Harvard University's Botanical Museum. His account of the impact that the Para rubber tree has had on mankind appeared in the Spring 1984 issue of *Arnoldia*.

The moss pink or thrift (*Phlox subulata*) is very effective in masses and borders. See "Collector's Notebook," page 25. Photographs from the Archives of the Arnold Arboretum.

The Arnold Arboretum of Harvard University, a non-profit institution, is a center for international bota research. The living collections are maintained as of the Boston park system. The Arboretum is suppo by income from its own endowment and by its me bers, the Friends of the Arnold Arboretum.

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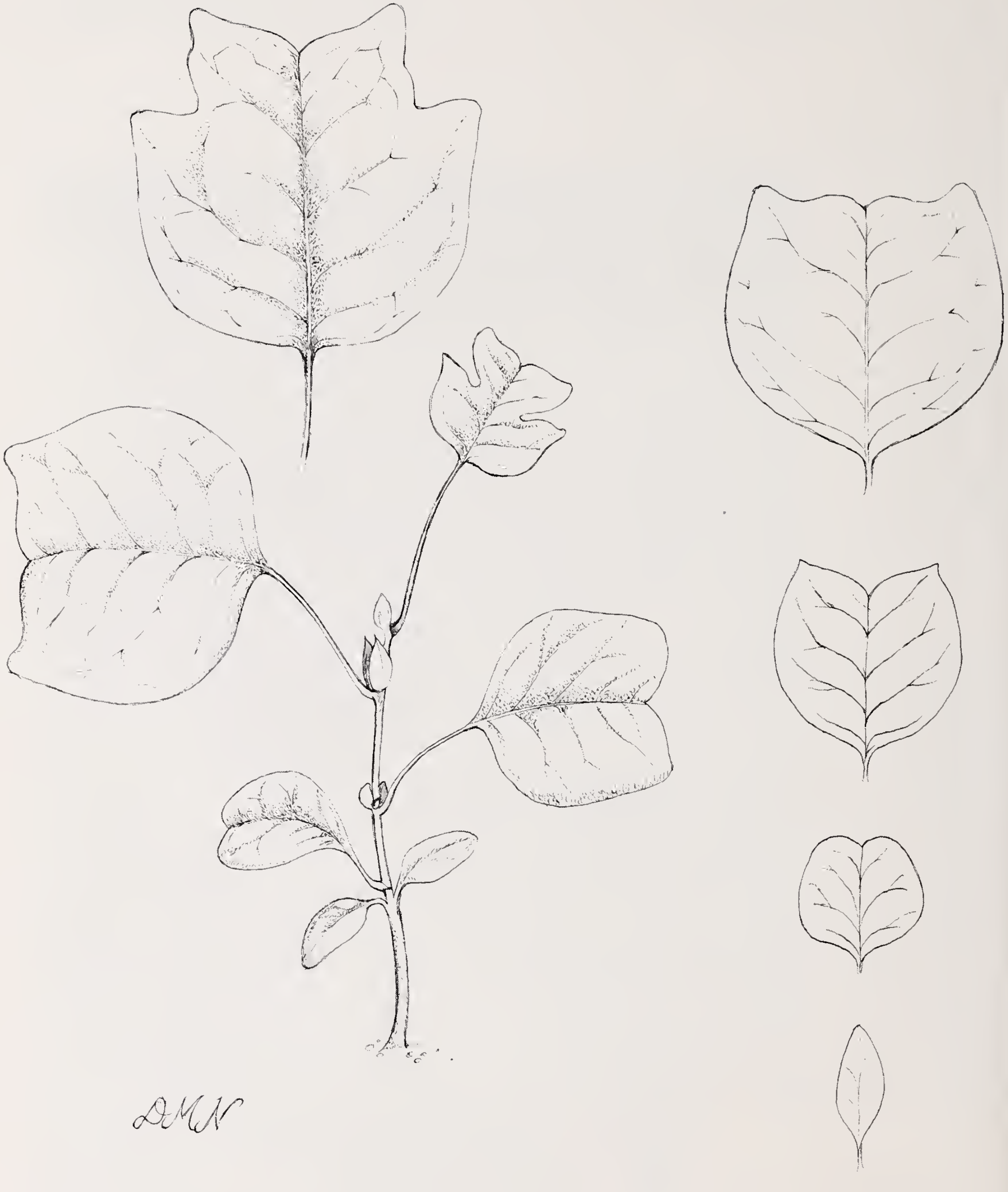
Edmund A. Schofield, Editor

Peter Del Tredici, Associate Editor

Front cover: The flower of *Liriodendron tulipifera* 'Fastigiatum'. (See "What's in a Leaf?," by Peter Del Tredici, page 3.) Photograph by Michael A. Dirr. *Opposite:* 'Ito Fukurin', a variegated cultivar of *Ardisia japonica.* (See "Cultivars of Japanese Plants at Brookside Gardens—II," by Barry R. Yinger and Carl R. Hahn, page 7). Photograph by Robert Rinker. *This page:* The flower and mature leaves of the tulip tree (*Liriodendron tulipifera,* as depicted in *Curtis' Botanical Magazine* in 1794. (See "What's in a Leaf?," by Peter Del Tredici.) *Inside back cover:* Two bunches of 'Thompson Seedless' grapes, one of which was sprayed with gibberellic acid (right), the other of which was not treated. (See "Chemicals that Regulate Plants," by John W. Einset, page 28.) Photograph by Abbott Laboratories. *Back cover: Rhodotypos scandens, Clethra alnifolia,* and *Acanthopanax sieboldianus* in the forest border of Central Park, Fifth Avenue between Seventy-second and Seventy-sixth streets. (See "Replacing the Understory Plantings of Central Park," by Geraldine Weinstein, page 19.) Photograph by Geraldine Weinstein.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The shape of the mature leaf of the tulip tree is the result of a process that began with the seed leaves, or cotyledons

What's in a Leaf?

Peter Del Tredici

The tulip tree, *Liriodendron tulipifera*, is unusual among the trees growing in the forests of eastern North America in combining stately massiveness with delicate beauty. Its unbranched trunk, often as much as six feet in diameter, rises straight up out of the ground like a pillar and seems to hold up the sky above the forest in which it grows. I have never seen another tree, save the redwoods of California, that can evoke such an impression. These magnificent trees have managed to escape destruction by growing on the hard-to-reach slopes of mountain ravines throughout the eastern half of our continent. In the moist coves of the Great Smoky Mountains of Tennessee and North Carolina, they can reach 150 to 200 feet in height.

It is the absolutely straight, unbranched bole of the tulip tree that makes it instantly recognizable in the forest. Many other trees are equally straight when they are young, but few maintain such straightness into maturity the way *Liriodendron* does. The lower branches seldom get thick enough to produce forked trunks, even those of specimens growing in full sun. In the dense shade of the forest, the tree usually sloughs off its lateral branches before they get much more than an inch thick, and the columnar trunk extends far up into the crown. This habit of self-pruning, as it is called, makes the tulip tree particularly desirable to the forester, who wants good, straight lumber, and a bit bothersome to the homeowner, who wants a neat front yard.

In contrast to the great size of the tulip tree is the delicateness of its flowers, which come out in May or June, depending on the latitude in which the tree grows. They are quite large as tree flowers go—about two inches long and equally wide when fully opened—and very beautiful. The petals are of an unusual light, bright green and have a conspicuous orange splash at their bases. The central core of the flower—the anthers and the gynoecium—is a clear yellow. Unfortunately, the petals and the leaves are so nearly the same color that you have to look closely to tell whether a tree is in bloom. Indeed, not until you actually have removed a flower from the background of leaves can you fully appreciate its beauty. The blossoms are faintly fragrant and, like those of other members of the magnolia family, are pollinated by flies, beetles, and bees.

As if its trunk and flower weren't enough to recommend the tulip tree, its leaf is noteworthy for its graceful, elegant shape. While normally there is a high degree of variability in form from one leaf to the next on the same tree, all leaves share a feature that makes them unmistakable—notched, rather than pointed, tips. So fixed in most people's minds is the idea that leaves should taper to a point, that many nineteenth-century botanists described the *Liriodendron* leaf as having three lobes, with the tip of the middle lobe cut off. Even those botanists who correctly described the leaf as having four lobes noted that the leaf's apex was "missing" or "chopped off." Evidently they had a preconceived notion about what a leaf should look like—some sort of archetype, from which modern forms are de-

Figure 1. Progressive variation in the shape of the tulip tree leaf, beginning with the simple, lance-shaped cotyledon (lower right) and culminating in a miniature version of a mature, four-lobed leaf (upper left). A seedling (lower left) bears all five variations. Drawing by Dawn M. Nunes.

rived—and tried to make *Liriodendron* fit the mold.

A better way to view the shape of the *Liriodendron* leaf is to follow its development in the germinating seedling. My own research in this regard suggests that the shape of the mature leaf is the result of a progressive, not a degenerative, process. The first structures the germinating tulip tree seedling produces are the seed leaves, or cotyledons, which are simple, lance-shaped structures that taper to blunt points. After the cotyledons, the next leaf is much simpler than those that the mature tree will produce. Almost round in its shape, it has a shallow notch at its tip. On the third leaf, two lobes begin to take shape on either side of this notch; on the fourth leaf, two lower lobes make their debuts. In healthy greenhouse-grown plants the next leaf, the fifth, has fully developed lower lobes and is a miniature version of the mature leaf. In effect, the plant is performing a kind of developmental dance in its progressive movement from one leaf to the next (Figure 1).

There is nothing unique about *Liriodendron* in its progressive leaf development. Botanists have recorded similar patterns in many other species. No one did it as early or as well as the great German poet–naturalist, Johann Wolfgang von Goethe, however. In 1790, Goethe published a little book entitled *Essay on the Metamorphosis of Plants,* in which he describes the life of a plant from the seed stage to the seed-producing stage as a series of internally regulated contractions and expansions. In his book, the leaf is considered the basic building block of the plant, and all other structures (except for the stem and the root, which he does not discuss) can be seen as modifications of the leaf. The key idea in *The Metamorphosis* is that plants are not static in their growth patterns but that, as they develop and grow, they change. Development, according to Goethe, is by its very nature dynamic, and the structures that a plant produces—the leaves and flowers—take on different forms depending upon whether they are produced during a phase of contraction or a phase of expansion. Regardless of what one feels about the correctness or accuracy of Goethe's ideas, his conception of growth as a dynamic process that results in a great deal of variation in leaf and flower structure would not be denied by anyone who works with plants. Goethe viewed the progressive development of the leaves of seedlings as part of the very first expansion phase in plant development:

> At each successive node the form of the [seedling] leaf attains greater perfection; the midrib lengthens, and the side ribs, which arise from it, extend more or less towards the margin. The different relations of the ribs to each other are the principal cause of the various shapes we observe in leaves which are notched, deeply incised, or formed of many leaflets, looking like little branches. The Date Palm is a striking instance of the most simple form of leaf becoming gradually but deeply divided. As the leaves succeed each other, the midrib lengthens, till at last it tears asunder the numerous compartments of the simple leaf, and an extremely compound, branch-like leaf is formed.

While the date palm shows increasing dissection of its leaves with each new leaf produced, the seedling leaves of the tulip tree show a dramatic change in their shape from one to the next. This can be seen most clearly by laying out the *Liriodendron* leaves in sequence. When I did this for the first time, I was reminded of Ernst Haeckel's famous nineteenth-century adage, "Ontogeny recapitulates phylogeny." In plain English, this means that the embryonic development of an individual organism encapsulates, summarizes, or repeats the whole evolutionary history of the species. While Haeckel's conception is not accepted as biological fact, it can help a person grasp the basic principles of growth and development. And so it is with the tulip tree. In arriving at the mature form of the leaf, the seedling must undergo a stepwise developmental process that may actually reflect the historical evolution of the leaf's shape. While this hypothesis is unprovable, it points out the dynamic nature of plant growth and evolution, much as Goethe's expansion–contraction theory does.

The pattern of change in the development of the *Liriodendron* leaf does not stop at seedling leaf number five, but continues throughout the life of the tree. As the plant matures, it produces larger and larger leaves. These reach their maximum size during the plant's juvenile stage—roughly between five and ten years of age. During this period, the tree can, and does, produce perfectly shaped four-lobed leaves up to twelve inches long and ten inches wide (Figure 2). (Why some trees produce larger than normal leaves during their adolescence is not certain, but enough different species do so to suggest that these larger than normal juvenile leaves serve some function.)

As the tree approaches sexual maturity in ten to twenty years, the leaf size shrinks to six inches by six inches. And in fully mature trees, the leaves are usually only about five inches by five inches. Curiously, these mature leaves often have one or two extra pairs of lobes at their bases (Figure 3).

The developing bud in *Liriodendron* is no less fascinating than the developing leaf. The careful anatomical work of W. F. Millington and J. E. Gunckel, in 1950, showed that the intriguing stipules that grow together to form the outermost bud covering should be considered lobes of the leaf, or more precisely, as "products of leaf base rather than of stem" (Figure 4). We thus have the rather unusual situation (found also in the genus *Magnolia*) where the lower lobes of one leaf are modified during development to protect the next leaf in line. Interestingly, these leaf-protecting stipules do not make their appearance until the second seedling node, those at the first node being little more than rudimentary flaps of tissue incapable of surrounding anything. This fact suggests that the stipules, like the other lobes of the leaf, develop in a stepwise fashion.

In addition to being of botanical interest, *Liriodendron* buds are aesthetically fascinating, particularly in the spring when they burst apart to reveal their contents. The great French naturalist, François Michaux, described this process better than anyone in his classic, *The North American Silva,* published in 1818:

> On the Tulip Tree, the terminal bud of each shoot swells considerably before it gives birth to the leaf: it forms an oval sack which contains the young leaf, and which produces it to the light only when it appears to have acquired sufficient force to endure the influences of the atmosphere. Within this sack is found another, which, after the first leaf is put forth, swells, bursts, and gives birth to a second. On young and vigorous trees, five or six leaves issue successively in this manner from one sack. Till the leaf has acquired half its growth, it retains the two lobes which composed its sack, and which are now called stipulae.

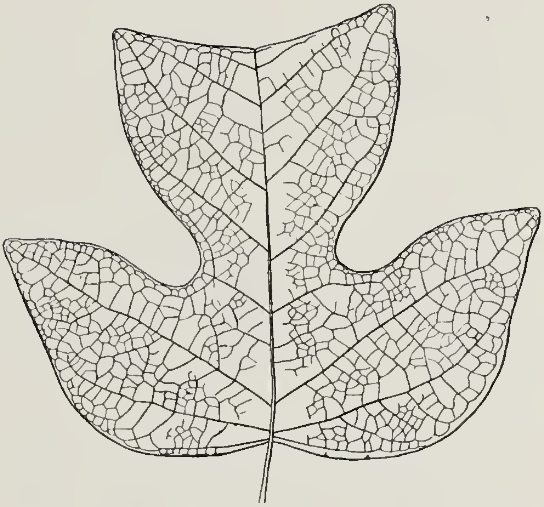


Figure 2. A four-lobed tulip tree leaf. This figure (and Figure 3) from *Proceedings of the U.S. National Museum,* Vol. 13 (1890). Both figures courtesy of the Museum of Comparative Zoology, Harvard University.

Figure 3. The leaf of a fully mature tulip tree.

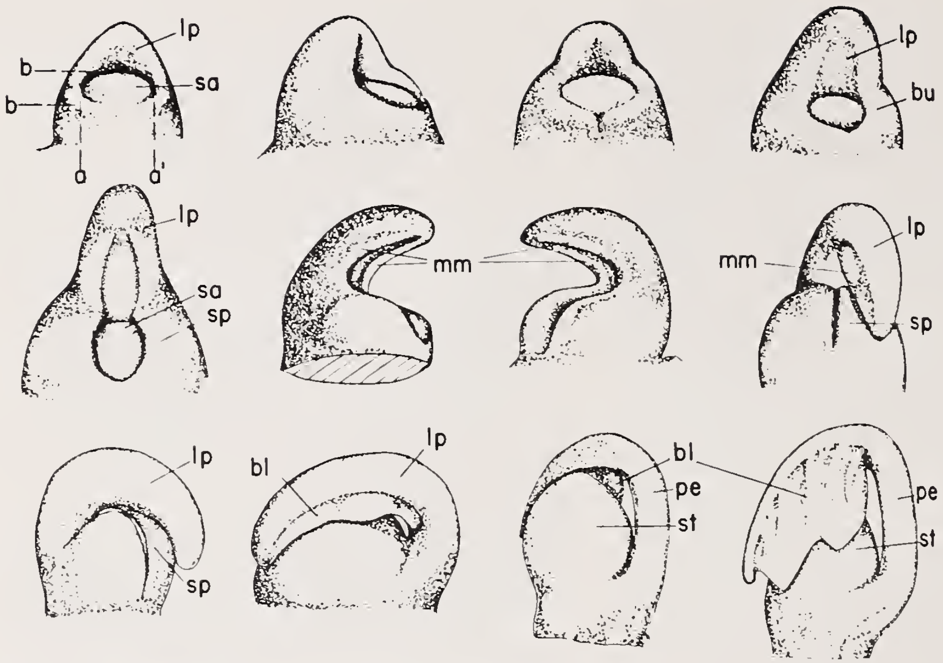


Figure 4. Development of leaf primordia and stipules of the tulip tree. From the research of W. F. Millington and James E. Gunckel, reported in the *American Journal of Botany.* Used with permission.

The *Liriodendron* bud is like a series of boxes within boxes—Russian dolls, if you will—that nest together perfectly. Unfolding one by one, the leaves seem to have no limit to their numbers. Although Michaux doesn't describe it, the buds usually stop producing leaves in June with the beautiful green, yellow, and orange flowers. The whole process is a bit like a symphony, slowly building up through a crescendo of larger and larger leaves to a floral fortissimo.

After all of this, are we close to describing the leaf of the tulip tree? The answer depends on when one chooses to look at its leaves: seedling leaves differ from adolescent leaves, which differ from the leaves on mature trees. The simplistic drawings found in most field guides do not do justice to the variation shown by an individual tree, let alone that shown by the species as a whole. While such variation may be difficult for the taxonomist to reckon with, it can be a source of delight and inspiration for the poet and the curious naturalist.

Related Readings

A. Arber. Goethe's botany. *Chronica Botanica 10,* No. 2, pages 67–124 (1946).

J. W. von Goethe. *Essay on the Metamorphosis of Plants.* Translated by Emily M. Cox. *Journal of Botany 1,* pages 327–345 and 360–74 (1863).

T. Holm. Notes on the leaves of Liriodendron. *Proceedings of the U.S. National Museum 13,* pages 15–35 (1890).

W. E. Millington and J. E. Gunckel. Structure and development of the vegetative shoot tip of *Liriodendron tulipifera* L. *American Journal of Botany 37,* No. 4, pages 326–335 (1950).

Peter Del Tredici is the Arboretum's assistant plant propagator and associate editor of Arnoldia. *He has written many articles for* Arnoldia *in the past several years.*

Second in a series

Cultivars of Japanese Plants at Brookside Gardens—II

Barry R. Yinger
Carl R. Hahn

Koten Engei

The Japanese employ a unique system of horticulture called *koten engei*, a term that resists easy translation but whose meaning is approximated by "cultivation of classical plants." In this traditional style of horticulture:

☐ The plants grown are groups of variants of species that, in their original form, are of modest demeanor. Most of the species are native to Japan and have insignificant or scarcely showy flowers.

☐ The variants are usually selections of mutated forms rather than hybrids. In most cases variations are of leaf shape and color rather than of floral characteristics.

☐ The kinds and degrees of variation are carefully classified and named, and certain kinds of variation are judged more valuable than others. A weak constitution is usually a "plus."

☐ The plants are always grown in pots instead of in the garden. The pots are thin, porous *raku* ware, usually with rough surfaces, shiny black glazes, and simple, fanciful decorations. Certain styles are appropriate for certain cultivar groups.

☐ Cultivars are assigned names that often allude to people, places, or events in classical Chinese or Japanese history.

☐ The cultivars are evaluated and ranked by societies devoted exclusively to variants of single species. The rankings are published periodically on a chart called a *meikan*, which recalls in its format the classical ranking board (*banzuke*) of *sumo* wrestling. The societies stage public exhibitions of the plants.

☐ Interest in the various species groups of cultivars is cyclical, being accompanied by recurrent waves of financial speculation in them.

Historically, many species have been treated as subjects for *koten engei* selection in Japan. Some are not grown now, but others—such as cultivars of *Rohdea japonica*, *Asarum*, and *Selaginella tamariscina*—have enjoyed enduring, if cyclical, interest for nearly 300 years. Some of the plants that will be described in our series are, or have been, part of the cult of *koten engei* and as such have, or have had, acceptable cultivar names. The first group of cultivars treated below—selections of *Ardisia japonica*—are part of the modern and classical *koten engei* tradition.

The Series

This article is part of Brookside Gardens's ongoing effort to reduce the considerable confusion in the nomenclature of cultivated plants from Japan. Our principal sources of information in this effort are the catalogs of nurseries that deal in a wide range of cultivated plants. We have also consulted the very few classic and modern Japanese texts that list and illustrate cultivated plants. Some of the names we publish may have to be changed as we find more sources of information. This long-term, serial effort should yield a reliable catalog of valid cultivar names for a wide range of Japanese cultivated plants.

In the first installment of this series (published in *Arnoldia*, vol. 43, no. 4, pages 3–19, Fall 1983), we described the special collections program in which the plants considered here are acquired, maintained, and evaluated at Brookside Gardens, Wheaton, Maryland, a publicly supported botanical and display garden of the Montgomery County, Maryland, park system. We also described in detail our approach to evaluating the acceptability of existing Japanese names as valid cultivar names, based on our interpretation of the rules and recommendations set forth in the *International Code of Nomenclature for Cultivated Plants.* We wish to establish and preserve in the Western literature legitimate Japanese cultivar names for the plants we are growing and to assign and register a suitable name where none exists that satisfies the *Code.* Readers interested in the details of our procedure for judging existing names should consult the previous article.

The inclusion of a plant name in this series does not imply that it is new either here or in Japan, or that we are its first or only introducer. We make no judgment about the garden value of the plants described; we hope that such information will emerge from an evaluation program now in progress under the supervision of Brookside Gardens's curator, Philip Normandy.

We will try to honor requests for more information about these cultivars and will be pleased to receive additional information as well. At present, time and money are not sufficient for the depth of research necessary to answer all questions that might be raised, but we will try to address questions as they arise. We intend to deposit specimens and documentation of published cultivars with the United States National Arboretum in Washington, D. C., as the plants continue to develop. Address correspondence to Carl R. Hahn, Maryland–National Capital Park and Planning Commission, 8787 Georgia Avenue, Silver Spring, MD 20907. **Please note that the Arnold Arboretum cannot supply these plants or information about them.**

Mr. Young June Chang, Seoul National University, Seoul, Korea; Mr. Philip Normandy, Brookside Gardens; and Mrs. Gennie Potter, Maryland–National Capital Park and Planning Commission, gave kind and invaluable assistance in preparing the manuscript, for which we sincerely thank them.

The Cultivars

The descriptions are of mature new growth in early summer. The leaves of some cultivars are different at other seasons, particularly during the colder seasons, when pink and red tones appear.

Ardisia japonica (Thunb.) Bl. 'Amanogawa' [Milky Way galaxy] (Yinger Collection No. 805)

Leaves of many shapes and patterns, puckered and often twisted, usually somewhat elongated or bearing large lobes of irregular sizes; 4 to 9 cm by 1 to 5.5 cm, with regularly or sparsely toothed margins. Those leaves without monstrous lobes, green with white or greenish-white central markings, those with lobes, light green with a white reticulate pattern and an irregular, darker-green border 1 to 2 mm wide, the lobes white. A vigorous clone.

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Beniyuki' [red snow] (Yinger Collection No. 810)

Leaves elongated and irregular, narrowing very acutely at the base, about half of them slightly lobed, the rest prominently and almost regularly lobed (resembling the leaves of *Quercus alba*); 5 to 10 cm by 2 to 4 cm. The slightly lobed ones with very narrow, white margins 1 to 2 mm in width that seldom invade the center of the leaf, the heavily lobed ones with broad, white margins up to 1.5 cm in width. Leaf surfaces slightly puckered, with slightly undulate margins. White areas becoming red in winter. A vigorous clone.

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Chiyoda' [a place-name] (Yinger Collection No. 806)

Leaves very irregular in outline, with no teeth on their margins; blades 5 to 11 cm by 1 to 3.5 cm, all bearing thin, white margins 1 to 2 mm in width that rarely invade the centers of the blades. Most leaves almost flat, with interveinal spaces sometimes raised or puckered. A vigorous clone.

Ardisia japonica 'Amanogawa'. Photographs by Robert Rinker.

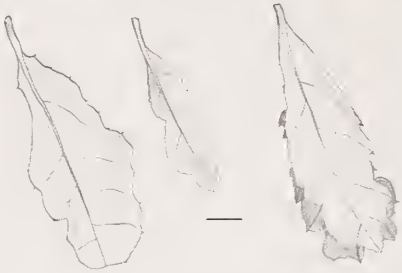
Ardisia japonica 'Beniyuki'

'Amanogawa'

'Beniyuki'

All drawings are by Young June Chang. The scale in each case is one centimeter.

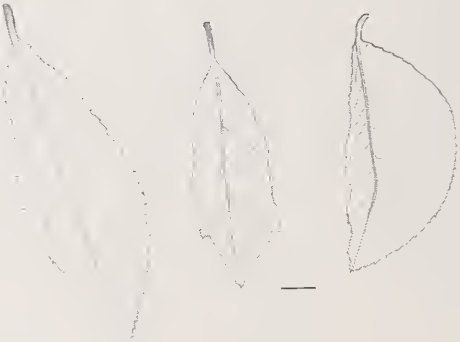
Ardisia japonica 'Chiyoda'



'Chiyoda'

'Chirimen'

Ardisia japonica 'Hinode'



'Hinode'

Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Chirimen' [crepe paper] (Yinger Collection No. 801)

Leaves long and narrow, 3 to 7 cm by 0.5 to 1.5 cm, their margins furnished with fine, regular teeth. All leaves light green with no variegation, with finely puckered surfaces, some leaves bearing as well a row of tubercles, or small, raised, crested growths, on each side of their center veins. A dwarf clone of slow growth.

Described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Hinode' [sunrise] (Yinger Collection No. 800)

Leaves large, 6 to 10 cm by 2.5 to 3.5 cm, with regular marginal teeth and occasional small white lobes breaking the regular outline; yellow-green, usually with large, irregular, paler-yellow-green areas in their centers, and usually flat with puckered interveinal spaces. Vigorous and fast-growing, but with short internodes.

Described and illustrated on page 169 of *Koten Engei Shokubutsu* (1977).

Ardisia japonica (Thunb.) Bl. 'Hi-no-Tsukasa' [official day] (Yinger Collection No. 812)

Leaves elongated, 4 to 10 cm by 1.5 to 3.5 cm, all distorted and very acutely narrowed at their bases, some with a few marginal teeth; medium green, many with occasional white, irregular marginal lobes. Leaf surfaces nearly flat, sometimes undulate, scarcely puckered. A moderately vigorous clone.

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica 'Hi-no-Tsukasa'

Ardisia japonica (Thunb.) Bl. 'Hokan Nishiki' [phoenix crown brocade] (Yinger Collection No. 816)

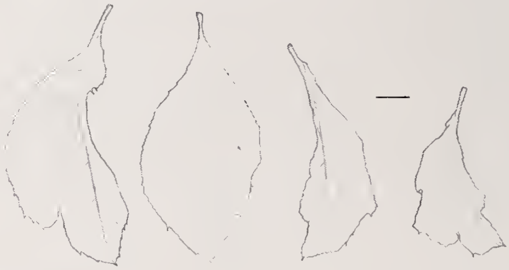
Leaves usually ovate, usually with blunt or rounded apexes and toothed or sparsely toothed margins, 4 to 7 cm by 2 to 2.5 cm (a very few irregularly lobed); green, with broad, irregular margins 1 to 10 mm wide often invading the leaves to or near their midribs. Margins yellow–green, tinged pink. Leaf surfaces nearly flat or slightly puckered, often undulate. A moderately vigorous clone.

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

'Hi-no-Tsukasa'

Ardisia japonica 'Hokan Nishiki'

Ardisia japonica 'Hoshiami'

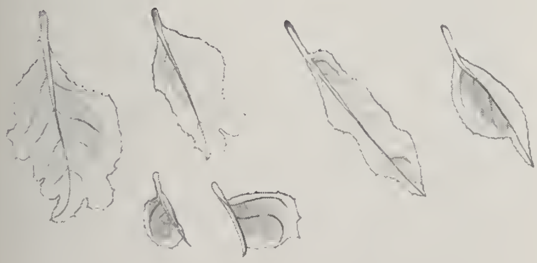


'Hoshiami'

'Hokan Nishiki'

'Ito Fukurin'

Ardisia japonica 'Kimigayo'



'Kimigayo'

Ardisia japonica (Thunb.) Bl. 'Hoshiami' [parched netting] (Yinger Collection No. 813)

Most leaves very distorted, few more or less ovate; most with toothed margins; 3 to 7 cm by 1 to 3.5 cm. About 25 percent of the leaves entirely green, the rest bearing fine, white reticulate patterns or irregular streaks of white. Most leaves cupped, puckered, or twisted. A clone of slow to moderate growth and congested habit.

Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Ito Fukurin' [thread border] (Yinger Collection No. 811)

Leaves ovate, mostly regular in outline, 4 to 7 cm by 2.5 to 3 cm, most with regularly toothed margins. All leaves medium green with thin white margins 1 to 2 mm wide, only occasionally slightly invading farther into the centers of the leaves. Leaf surfaces nearly smooth and only slightly puckered. Of moderate to vigorous growth.

Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica (Thunb.) Bl. 'Kimigayo' [Japan's national anthem] (Yinger Collection No. 799)

All leaves distorted, of several shapes; most more or less ovate, about 3.5 to 6 cm by 1.5 to 3 cm. Leaf margins irregularly toothed, often with small lobes at various points along the margins. Leaves yellow–green, with darker-green central blotches; marginal lobes white. All leaves puckered and twisted, some with prominent, bubble-like swellings near their centers. Somewhat dwarf and slow-growing.

Illustrated on page 98 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

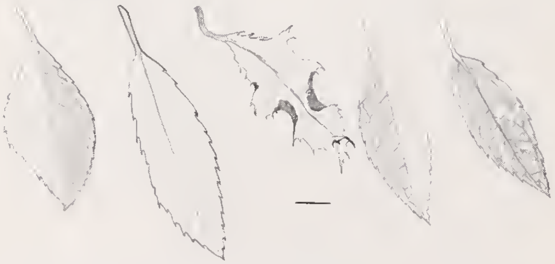
Ardisia japonica (Thunb.) Bl. 'Koganebana' [gold flower] (Yinger Collection No. 817)

Leaves small, ovate to elongate, regular or irregular in outline, 2.5 to 4 cm by 1 to 2 cm, the margins with occasional teeth. Leaves medium green, usually with narrow or broad white margins 1 to 6 mm wide. A few leaves almost entirely white. Leaf surfaces nearly flat or puckered. A dwarf clone of slow, dense growth.

Illustrated on page 97 and described on page 254 of *Shumi no Koten Shokubutsu* (1975).

Ardisia japonica 'Koganebana'

'Koganebana'



Ardisia japonica 'Shirofu Chirimen'

Daphne odora 'Ringmaster'

Daphne odora 'Zuiko Nishiki'

Ardisia japonica (Thunb.) Bl. 'Shirofu Chirimen' [white variegated crepe paper] (Yinger Collection No. 804)

Leaves of regular outline, elongated, with acutely pointed apexes; blades 3 to 5 by 1.5 to 2 cm; margins toothed. Some shoots and leaves all green or all white, the rest with sectoral white markings or flecks of white. A few leaves equally divided longitudinally into green and white halves. Most leaves flat and scarcely puckered, a few with undulate margins. A rather dwarf selection.

Illustrated on page 96 and described on page 293 of *Shumi no Koten Shokubutsu* (1975).

Carex phyllocephala T. Koyama 'Sparkler' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 1403)

Leaves, which persist for at least two years, lime green to dark green, with 1- to 4-mm-wide white margins. One to four longitudinal streaks of white often within the green portions of the leaves. Sheaths at the bases of the leafstalks purplish. A rare and attractive variant of a rare plant.

Sold by Ishiguro Momiji En (nursery), Nagoya, Japan, as *fuiri tenjiku-suge* (variegated *Carex phyllocephala*).

The following two plants are selections of *Daphne odora*, a Chinese shrub long popular as a garden plant in Japan. Many cultivars have been selected for pot culture as well, especially those with leaves variegated in various patterns, fasciated shoots, or twisted leaves. The classic works *Somoku Kihin Kagami* (1827) and *Somoku Kinyoshu* (1829) list twenty-one variants. The two more-modern cultivars described below are notable for their floral display as well and seem not to be included among the cultivars listed in the classics.

Daphne odora Thunb. 'Ringmaster' [a new cultivar name assigned by Carl R. Hahn] (Yinger Collection No. 1894)

Leaves green with 2- to 4-mm-wide margins of cream or pale yellow. Flowers 2 cm across, with a tube 1 cm long; pure white, appearing relatively late.

A very beautiful selection combining white flowers with clear marginal variegation to produce plants that are unusually striking in flower.

Grown in Japan by Mr. Yoshimichi Hirose, Iwakuni City, Yamaguchi, Japan. Described, but not named, on page 51 of the 1911 catalog of the Yokohama Nursery Company, Yokohama, Japan.

Daphne odora Thunb. 'Zuiko Nishiki' [fragrant brocade] (Yinger Collection No. 279, No. 1794, and No. 1920)

Leaves green, not variegated. Flowers dark pink (Rhodamine purple or Fuchsia purple in the 1938 Royal Horticultural Society's Colour Chart) or white. On young plants, flowers usually all of one color or the other, both colors appearing on the same plant as the plant matures. All the flowers of an umbel usually of one color, but some umbels having both pink and white flowers, and a few individual flowers showing sectoral (chimeral) patterns. Individual flowers large, 2 to 2.5 cm across, each with a tube 1 cm long. Corolla lobes obtuse or rounded at their tips. Flowers borne in large, rounded umbels of 15 to 25 flowers. A very beautiful plant marketed under several names, including *"sakiwake"* and *"shibori,"* both of which are applied to two-colored flowers or inflorescences.

Described and illustrated on page 33 of the Fall 1980 catalog of Kairyo En (nursery). Grown by Kairyo En, Angyo, Japan, and several other major nurseries.

Distylium racemosum Sieb. & Zucc. 'Akebono' [*dawn*] (Yinger Collection No. 269)

Leaf blades 5 to 10 by 2 to 5 cm, mostly about 7 cm by 3 to 3.5 cm, persisting two years. One-year-old leaves creamy white, all on new shoots; some below the apexes of the shoots speckled or veined green. Two-year-old leaves dark green with no markings. Stems of new shoots creamy white or sometimes dark pink, those of older shoots green. A vigorous plant with obliquely ascending branches. A very distinctive variegated clone, one of several listed in modern and classical Japanese sources.

Described under the name 'Akebono' [dawn] on page 11 of Catalog No. 62 (Fall 1978–Spring 1979) of the Asahi Shokobutsuen (nursery), Okazaki, Aichi Prefecture, Japan.

Distylium racemosum Sieb. & Zucc. 'Guppy' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 274)

Leaves green, not variegated, 3 to 5 cm by 1 to 2 cm, with short (5 to 15 mm) internodes. Typically

Distylium racemosum 'Akebono'

makes 4 to 8 cm of new growth per year. A dwarf cultivar making a dense, rounded shrub of congested growth.

Similar to a clone described and illustrated on page 42 of the explanation volume accompanying the facsimile reprint of the classic Somoku Kihin Kagami *(1976). The clone listed, which the text explains is probably not in existence now, is called "*koba hizon*" [small-leaf* Distylium*]. No measurements are given, but the plant pictured has leaves that seem to be proportionally wider than those of the clone we describe here.*

Grown and sold by Garden Wako (nursery), Takarazuka, Osaka-fu, Japan.

Houttuynia cordata Thunb. 'Chameleon' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 714 and No. 824)

Leaves dark green with variable broad margins that often invade the centers of the leaves in broad sectoral patterns. Margins creamy white or yellow, often tinged with pink; in sunny locations bright-red and strong-pink shades often dominate. Green interiors of the leaves usually streaked or splashed with gray–green, and a green reticulate pattern may appear on the lighter margins. Outlines of leaves less regular than those of the species, the margins often undulate. Number of white, showy bracts subtending the inflorescence (normally four) variable in this clone. A very showy variegated selection.

A similar cultivar is listed in the classic Somoku Kinyoshu, *illustrated and described on page 73 of the explanation volume accompanying the facsimile reprint (1977). However, that clone appears to have irregularly splashed leaves with no sign of the distinct marginal variegation of 'Chameleon'.*

Sold by several nurseries in Japan as *"fuiri dokudami"* [variegated *Houttuynia*] (for example, Garden Wako [nursery], Takarazuka, Osaka-fu, Japan).

Ilex integra Thunb. 'Green Shadow' [a new cultivar name assigned by Barry R. Yinger] (Yinger Collection No. 718)

Leaf blades 5 to 9 cm by 1.5 to 3 cm. Leaves medium gray–green with irregular creamy-white margins 1 to 5 mm in width that sometimes invade nearly to the midveins. Irregular patches of paler gray–green, in broken patterns, also occupying one-third to one-half of the green portions of the leaf blades. The creamy-white areas often suffused with pink on new growth. A vigorous and stable clone.

The classic, Somoku Kinyoshu *(1829), lists six cultivars of* Ilex integra *with variegated or contorted leaves. This selection seems to be different from those listed there.*

Grown by Kiraku En (nursery), Mito, Ibaraki, Japan, as *"fuiri mochi-no-ki,"* [variegated *Ilex integra*].

Ophiopogon japonicus (L. *f.*) Ker-Gawl. 'Torafu' [tiger variegation] (Yinger Collection No. 1681)

Leaves to 15 cm long, 3 mm wide, green, with one to four latitudinal bands of pale yellow fading to creamy white. Most bands 1 to 5 cm wide. Some leaves entirely green or, less often, entirely creamy white.

Grown by Kairyo En (nursery), Angyo, Japan.

Pinus parviflora Sieb. & Zucc. 'Fubuki Nishiki' [snowstorm brocade] (Yinger Collection No. 1908)

Needles 2 to 4 cm, mostly about 3 cm, long; not curved; green, those recently produced with a glaucous bloom. Most needles banded with creamy white. Of these, the most common pattern a single band, 5 to 10 mm wide, on the upper half of needles. Band sometimes flecked with green so that there seems to be a sucession of smaller bands. Tips of needles often creamy white. Habit dense and somewhat congested, with about 4 to 9 cm of new growth each year.

Most similar to P. parviflora *'Janome' (actually, two distinct clones) and 'Ogon'. 'Janome' is distinguished by its strongly curved needles and green-tipped needles in both so-named selections. 'Ogon' is distinguished by its short, densely tufted needles, which are uniformly yellow except at the base.*

Illustrated on the cover of the Fall 1977 catalog of Kairyo En (nursery), Angyo, Japan, and described on the inside cover. Sold by Kairyo En and other nurseries.

Cultivar Update

In the Fall 1983 issue of *Arnoldia*, we assigned the name 'Sundance' to a cultivar of *Aucuba japonica* (Yinger Collection No. 267). We have since discovered a validly published name for this clone that is acceptable under the *Code*. Thus, we wish to nullify our name 'Sundance' in favor of the name 'Meigetsu' [the Japanese spring and autumn equinox], which is illustrated and described on page 9 of Catalog 62 (Fall 1978–Spring 1979) of Asahi Shokubutsuen (nursery), Okazaki, Aichi Prefecture, Japan.

General Bibliography

Books and Periodicals

Bailey, Liberty Hyde, Ethel Zoe Bailey, *et al. Hortus Third.* New York: Macmillan, 1976.

Bean, W. J. *Trees and Shrubs Hardy in the British Isles.* 4 vols. London: John Murray, 1970, 1973, 1976, and 1980.

den Ouden, P., and B. K. Boom. *Manual of Cultivated Conifers.* The Hague, Netherlands: Martinus Nijhoff, 1978.

Hillier, H. G. *Hillier's Manual of Trees and Shrubs.* Newton Abbot, England: David and Charles, 1972.

International Commission for the Nomenclature of Cultivated Plants of the International Union of Biological Science. *International Code of Nomenclature for Cultivated Plants.* C. D. Brickell, Chairman, Editorial Committee. Utrecht, Netherlands: Bohn, Scheltema, and Holkema, 1980.

Kintaro. *Somoku Kihin Kagami.* 3 vols. Japan, 1827 (Reprinted in facsimile, Tokyo: Seiseido, 1976). (In Japanese).

Koten Engei Shokubutsu. Garden Life Edition. Tokyo: Seibundo Shinkosha, 1977.

Krussmann, G. *Handbuch der Laubgeholze,* 2nd ed., rev. 3 vols. Berlin: Verlag Paul Parey, 1976–78. (In German).

Mizuno, Tada-aki. *Somoku Kinyoshu.* 7 vols. Japan, 1829 (Reprinted in facsimile, Tokyo: Seiseido, 1977). (In Japanese).

Ohwi, Jisaburo. *Flora of Japan.* Edited by Frederick G. Meyer and Egbert H. Walker. Washington, D.C.: Smithsonian Institution, 1965.

Shumi no Koten Shokubutsu. Edited by Kujiko Kamisaki. Toyko: Shufu no Yusha, 1975.

The Royal Horticultural Society. *Horticultural Colour Chart.* 2 vols. London, 1938 and 1941.

Tsukamoto, Yotaro, *et al. Explanation Volume To Accompany 1976 Facsimile Reprint of* Somoku Kihin Kagami. Tokyo: Seiseido, 1976. (In Japanese).

———. *Explanation Volume To Accompany 1977 Facsimile Reprint of* Somoku Kinyoshu. Tokyo: Seiseido, 1977. (In Japanese).

Valvanis, William N. "Japanese five-needle pine," in *Encyclopedia of Classical Bonsai Art,* Vol. 2. Atlanta, Georgia: Symmes Systems, 1976.

Yokoi, Masato, and Yoshimichi Hirose. *Fuiri Shokubutsu.* Tokyo: Seibundo Shinkosha, 1978. (In Japanese).

Catalogs (in Japanese unless otherwise noted)

Asahi Shokubutsuen, Okazaki, Aichi Prefecture, Japan; *Catalog No. 62*, (fall 1978–spring 1979).

Chugai Nursery Company Kanagawa Prefecture, Isehara-shi. *Catalog No. 11.*

Fuji En, Osaka, Takarazuka. Fall 1973, spring 1978.

Kairyo En, Saitama Prefecture, Kawaguchi-shi, Oji Kamito. Spring 1966; fall 1970, spring 1972, fall 1972, spring 1973, fall 1973, spring 1974, fall 1974, fall 1975, spring 1977, fall 1977, spring 1978, fall 1978, fall 1979, fall 1980, spring 1981, spring 1982.

Nagoya Engei, Nagoya, Naka-ku. *Catalog No. 11* (fall 1978).

Nihon Kaki, Saitama Prefecture, Kawaguchi-shi, Ishigami. Fall 1973, spring 1974, fall 1979, spring 1980, spring 1981, fall 1981, spring 1982.

Sakata Nursery Company, Yokohama, Minami-ku, Nagada-cho. Spring 1978, fall 1978, spring 1979, spring 1981, fall 1981.

Shibamichi Kanjiro Company, Limited, Saitama Prefecture, Kawaguchi-shi, Akayama. Commercial catalog, 1976–77.

———. *Trees and Shrubs for Your Garden.* April 1979. (In English).

Shunko En, Tokyo, Itabashi. Spring 1972, fall 1972, spring 1979.

Sosei En, Hyogo Prefecture, Takarazuka. Fall 1976, spring 1977, fall 1979.

Yinger, Barry R. *Japanese Trees and Shrubs for Your Garden.* Saitama Prefecture, Kawaguchi-shi, Akayama: Shibamichi Kanjiro Company, Limited, 1981. (In English).

Yokohama Nursery Company, Yokohama, 1911–12. (In English).

Barry R. Yinger is curator of the Asian Collections at the United States National Arboretum. Carl R. Hahn is chief of horticulture of Maryland–National Capital Park and Planning Commission, Silver Spring, Maryland.

Five years of experience yield the formula for success

Replacing the Understory Plantings of Central Park

Geraldine Weinstein

A century after Central Park was created, few vestiges of its original understory of shrubs and trees remained, despite a major replanting that was done in the 1930s. Depleted financial resources, misguided attempts at landscape management, inadequate maintenance, and the impact of millions of visitors were the major culprits. Recognizing the importance of shrubs and understory trees in the Park's design and ecology, the Central Park Conservancy and the New York City Department of Parks and Recreation began to replant the understory in the spring of 1980.

Basing their approach on the Park's history, on growing conditions in the Park, and on the desires of parkgoers, the Park's managers and landscape architects have been focusing on the ability of specific understory plantings to accomplish aesthetic and ecological objectives. They have found that the key steps in successfully reestablishing the understory are analysis of the site, the selection of plants, appropriate maintenance practices, and continual evaluation of each plant's performance.

Construction of Central Park began in 1858, during an era of intense botanical exploration. The idea of bringing plants from abroad greatly appealed to Frederick Law Olmsted and Calvert Vaux, the Park's designers, since an expanded choice of plants would make it easier for them to carry out their design intentions. Combining exotic and native species, they provided a multitude of contrasts in plant texture, color, and form, offering visitors to the Park a continual and fascinating change in scenery. *Leucothoë fontanesiana* (*L. catesbaei*), *Mahonia aquifolium*, and a myriad of *Rhododendron* species brought bold texture and deep color to the landscape, while *Caragana arborescens*, *Cytisus scoparius*, and other fine-textured plants provided a counterpoint.

Fruits of the many species of *Cotoneaster*, *Lonicera*, and *Viburnum* also wove color through the landscape. In autumn, the diversity of color was heightened by the foliage of *Rhus typhina*, *Euonymus alatus*, and *Hydrangea quercifolia* and, in winter, by the twigs of *Kerria japonica*, *Cornus sericea*, and *Vaccinium angustifolium*.

Through the widespread planting of roses, spireas, lilacs, azaleas, and rhododendrons, floral displays became part of the Park's landscape. But in choosing from a wide array of plant species, the Park's designers did not always give horticultural considerations the attention they deserved.

First and foremost, Olmsted and Vaux used plants—especially shrub and understory species—to give specific aesthetic character to a site or to complement such existing features of the landscape as lakes, streams, and meadows. Although Olmsted and Vaux planned the understory with a flawless eye, conditions at a site were not always favorable to the species they planted there. Some of the species probably found the Park's environment as inhospitable in the nineteenth century as they would find it now. Of the plants listed on the 1873 survey of the Park, *Aucuba japonica*, *Kalmia angustifolia*, *Andromeda polifolia*, and *Myrica cerifera* could not have found conditions particularly favorable.

The 1873 survey indicates that the species planted in the Park came from a wide range of habitats. Shrubs familiar in garden settings—*Potentilla* spp., *Buxus* spp., *Hydrangea macro-*

The Fifth Avenue border planting of *Berberis thunbergii* and *Rhodotypos scandens.* Photographs by the author.

phylla, Cotoneaster spp., *Hypericum perforatum*—were used, as were shrubs more often seen in their native habitats—*Lindera benzoin, Viburnum dentatum, Clethra alnifolia*, for example.

As much as diversity, scale characterized the shrub and understory plantings. For Olmsted and Vaux, understory planting had to be of considerable scale and depth, allowing the eye to wander, uninterrupted, over large areas of the landscape, evoking a sense of space and dimension. A powerful contrast was to exist between the Park and the surrounding city, where cement and concrete loomed before one's eyes, continually cutting off views of what might lie beyond. Shrub plantings of considerable depth and length would add another dimension to its environment, as well as another texture to the Park's landscape. Installed throughout woodlands, at the edges of meadows, and on the banks of streams and ponds, extensive shrub and understory plantings created environments rich in botanical and ecological diversity. Wildlife found varied sources of food and excellent protective cover. Visitors to the Park saw before themselves the same degree of harmony and contrast among plants that characterizes natural landscapes.

Design and Management Considerations

The objectives of the current replanting echo those of Olmsted and Vaux but have been expanded to meet additional management needs.

Growth habit, foliage texture, and times of flowering and fruiting are still part of the design and plant-selection process. However, management issues pertaining to the Park's appearance as a well maintained and thriving urban green space receive no less emphasis. As in early Park plantings, shrubs and understory trees are currently used to provide soft, undulating edges to wooded areas of the Park. The understory created between canopy trees and the ground surface is particularly important at entrances and along the Park's perimeter, where visitors get their first impression of Central Park as a naturalistic landscape.

Reiterating an important concept of Olmsted and Vaux's, landscape architects at the Conservancy are planning large-scale plantings of shrubs for selected sites along the edges of lawns. Throughout much of the Park, lawns are defined by pavement. The hard visual impact of asphalt paths is offset by lush and vigorous understory plantings, which also define the edges of meadows. Thus the lawns are set off and highlighted as more irregular and undulating spaces than before.

In addition, naturalistic edges of shrubs and understory trees are being planted on the banks of lakes, ponds, and streams in the Park to halt siltation. This process begins with an assessment of the total watershed area to determine whether and, if they will, where understory plantings will minimize erosion of surrounding slopes and adjacent areas. The process ends with an effective waterside planting that will stabilize the banks and shoreline. The waterside planting must have additional merit as a wildlife habitat, providing both food and cover.

Soil erosion in Central Park adversely affects not only its bodies of water. Throughout the Park, the growth and establishment of plants, especially of trees and ground covers, are threatened by the continual loss of topsoil. Erosion undoubtedly became a problem in Central Park soon after the first half million cubic yards of topsoil were brought to the Park during its construction. Other factors related to the erosion problem have been with the Park since its beginning. At any given site, at least one of the following factors is involved: design, soil texture, environmental factors, and use of the Park. Understory planting in Central Park is intended to compensate for the erosion-prone soil, intense use of the Park, difficult-to-manage or -design areas, and harsh microclimate.

Intensity of use in particular is a problem, as the feet of 14,000,000 visitors leave their imprints each year. The problem is most obvious in the dusty and constantly eroding cow paths that crisscross areas in the Park, and on steep slopes, where any major amount of foot traffic results in considerable loss of topsoil. Understory planting is used to manage the circulation patterns of visitors. Such "barrier plantings" protect easily eroded areas, newly restored landscapes, and lawn areas. The species of shrubs chosen are not necessarily thorny, but by their mass and visual impact they effectively deter foot traffic.

In summary, design intentions and management concerns have resulted in specific planting objectives for the restored understory, namely, to control erosion, supply food and cover for wildlife, provide a naturalistic understory in the Park's woodlands, stabilize banks and shorelines, lend spatial definition to landscape sites, and assure the integrity of Central Park as a naturalistic landscape, even at its entrances and on its periphery.

Site Considerations

In any restoration project, if the plant species chosen deal successfully with the existing use and environmental problems, then the design intent will be clearly conveyed; otherwise, it will crumble. After the site has been analyzed, plant material must be chosen with as much knowledge and information as are available to the horticulturist and the landscape architects. Strong emphasis is placed on the use of native species whenever possible, and on integrating broadleaf evergreens into the planting. Existing plant lists can indicate which species are tolerant of shade, salt, or flooding, and which will help prevent erosion. However, existing lists usually do not take into account the many adverse environmental conditions of an urban site.

Central Park is a built landscape. Even its soil, which must support plants, is built. The characteristics of urban soil differ sharply from those of natural soils. Structural and textural inconsistencies in the profile of an urban soil create barriers to the movement of air and water into the soil. In addition, compaction of the surface and subsurface layers of soil decreases the amount of air and water that are available to plants, a common problem in soils that are affected more by people and machines than by natural processes. Both periodic flooding and drought can occur within soil layers.

The climate of Central Park, like the climates of other "green islands" in cities, is strongly modified by the areas around it. Winds tunnel between tall buildings, and heat radiates long into the evening, having been trapped in masses of asphalt and concrete during the day.

It is significant, too, how the characteristics of urban soils and microclimates intensify the effects of seasonal changes in temperature. Unlike actual islands, which are protected from climatic extremes by the water around them, urban "islands" have very few ameliorating influences. Temperatures in the soil and air are often extreme, especially in shallow and compacted soils.

Perhaps the most important site consideration is the effect wrought by people. "People-pressure diseases" of urban trees also affect the understory. While most actual islands are inaccessible to large numbers of people, urban islands are created for people. In fact, the intense use of Central Park, despite the damage it does to vegetation, is the Park's greatest attribute. Central Park was created to attract the citizens of New York; it provides them with relief from the city's steel and concrete.

The Border Planting

The restoration along Fifth Avenue between 72nd and 76th Streets was the first attempt to reestablish a border planting at the edge of the Park. The planting was gradually extended, creating a forest edge along the Park's perimeter, adjacent to Fifth Avenue.

This planting lies between two Park entrances. One, the entrance at 72nd Street, a major thoroughfare in the Park, leads to the Mall, Sheep Meadow, and Bethesda Terrace—all of which are major focal points in Central Park. Immediately north of this entrance is the path leading down to the Conservatory Water, which is a model-sailboat pond in spring and summer and an attractive site for ice-skating in winter.

While a proliferation of architectural styles and forms occupies the adjacent city streets, the forest edge just inside the Park is a coherent and free-flowing naturalistic landscape, reflecting harmony along its entire length. From the Park wall, the forest edge slopes either down toward the Conservatory Water or up a short rise toward the 72nd Street entrance. Understory plants weave through and around canopy trees. Unlike the city streets, which are spatially defined by blocks, the border planting conveys the feeling of a contiguous forest.

On sunny days, the lawn around the Conservatory Water is crowded with people. On weekdays, hundreds of people pass through the 72nd Street entrance, on weekends, thousands. During certain special events, hundreds of thousands of people pour into the Park. The spilling over of people from the entrance onto the border planting is a perennial problem, one that affects both the design of the planting and the plants used at the site. The entrance at the other end of the border planting is much smaller in scale—just a gap in the Park wall, and a pathway leading in—and is far less used by visitors. There is a very popular playground just to the north, making large numbers of school children a normal part of the landscape.

In terms of climate, the Park's perimeter along Fifth Avenue is colder by far in winter than all other sites in the Park. The wind coming off the East River increases in force as it whips around and through row upon row of skyscrapers before

Myrica pensylvanica growing on a rocky ledge on The Point.

striking the Park with enormous impact.

Because the perimeter planting faces east, parts of it receive more sunlight than other areas of the Park, particularly in winter. Unfortunately, the winter sun does more harm than good to plants because it can dry them out.

The most striking visual features of the site are the many large and magnificent canopy trees and the extensive steep slope that characterizes the entire planting. In this part of the Park's perimeter the slope extends down from the base of the Park wall, becoming a potentially scenic and dramatic backdrop to the lawn areas below.

Although the trees were for the most part in good condition, the slope was, with few exceptions, bare of understory planting. It was also bare of leaf litter, since the leaves from the canopy trees are swept off the slope by the wind and people onto the lawn areas below. During heavy rainstorms the Park wall adds to the erosion problem: Rain pours down the side of the stone wall and shoots down the slope, leaving rills and gullies behind. As this site is adjacent to the Park wall, we were not surprised to find fill and heavy subsurface layers within the soil profile. To provide a supportive soil environment, truckloads of leaf mold were brought to the site. Where feasible, the leaf mold was rototilled into the soil. Where a Rototiller could not be used, the leaf mold was worked in with grub axes and shovels.

To create a forest edge at the site, understory planting would have to stop erosion effectively. Shrubs and understory trees capable of doing this would be those species able to deal with the adverse effects of wind, heat, sun, and people, as

Cornus racemosa, placed to soften a planting of *Berberis julianae* used to define a path to The Point.

well as with the limitations of deep shade and intense competition from the roots of the many existing mature trees. Over two thousand shrubs and understory trees, consisting of twenty-two species, were used at the site. *Hamamelis virginiana*, *Euonymus alatus*, *Rhodotypos scandens*, and *Viburnum siedboldii* are the "anchors" of this landscape. They have proven themselves in other sites in the Park, and were used to give cohesiveness to the planting and to link this landscape to other sites in the Park. It was also hoped that they would uphold the planting and the design if any of the other plants chosen proved to be mistakes.

Hamamelis virginiana was the principal understory tree used. This species had already indicated its tolerance of severe exposure, drought, and flooding at other sites in the Park. Its wide-spreading habit provides an effective contrast to the many verticals of the major-story trees. Placed at the top of the slope, it breaks the force of the wind and rain and provides a buffer for less adaptable plants on the site. Even from outside the Park, the graceful form and yellow flowers are a welcome contrast to the traffic congestion on the avenue.

Although somewhat stiffer in habit, *Euonymus alatus* 'Compactus', with its dense and compact form, also protects the soil from the pounding of heavy rainfalls. When mass-planted, it provides an equally dense buffer against careless foot traffic. Its density deters visitors from ploughing through the planting. In the autumn, the broad spatial effect of its pink-rose foliage provides additional depth and interest to the border planting.

While both *Viburnum dilatatum* and *Viburnum lantana* were used, *Viburnum sieboldii* has proved more successful. Its lustrous foliage is an especially welcome sight during the hottest part of the summer. It rarely indicates drought or heat stress, and it grows more vigorously than other species of *Viburnum,* with *Viburnum prunifolium* being the only exception.

Rhodotypos scandens is another park favorite, much admired because it tolerates almost anything. With maintenance, it is a very vigorous grower. Its graceful, wide-spreading habit contrasts effectively with the more upright *Euonymus alatus.* At this particular planting site, it flowers for nearly four weeks. The black, beadlike berries are as attractive to wildlife as to people.

Acanthopanax sieboldianus has proved very effective at stopping erosion because it deters foot traffic. It is easily established and is a very vigorous grower, so vigorous, in fact, that it often hinders the growth of less competitive plants growing nearby. Its very-fine-textured foliage lightens up an entire planting. It protects the soil because it virtually covers it with its moundlike and wide-spreading habit.

At the base of the slope, in a wet area, we were successful with a bare-root planting of *Cornus sericea.* While we had often been unsuccessful planting *Cornus* species balled and burlapped, we incurred no losses with the planting at this site.

As all of the above species flourish, they provide protection for rhododendrons and *Kalmia latifolia.* Though not widely used throughout the planting, the contrast between their bold, broadleaf foliage and the lighter texture of the deciduous material magnifies their impact. While it would be nice to use evergreens at the edge of a border planting, so that they could be seen from the street, it doesn't work that way. They are difficult to reestablish, are easily desiccated by the wind and sun, and are intolerant of the heat, urban soils, and disturbances in general. While an environment suitable for rhododendrons, laurels, and azaleas could be provided, site conditions proved totally unsuited for other species selected.

Amelanchier canadensis is a favorite understory tree, but it has not fared well on this site. Heat, surface campaction, and frequent disturbance by people set it back substantially. In Central Park it is slow to establish, even when maintenance is provided, and its stems are easily broken.

Along with *Amelanchier canadensis, Clethra alnifolia* and *Ilex verticillata* found the site far too dry for their liking. Even with irrigation and mulching, neither species thrived. Like *Amelanchier, Clethra* is particularly difficult to establish. While healthy examples of all three species can be found elsewhere in the Park, the fatality rate has been high, considering the numbers planted during the last two to three years (nearly one thousand *Clethra* plants). *Clethra* and *Amelanchier* are doing well at waterside plantings, even though the soil in which they were planted is not wet. The breezes from the water lower the temperature and provide a degree of air circulation missing from the border planting, where the winter winds are not replaced by any cool summer breezes. In addition, at the waterside sites, both species suffer far less disturbance.

Ilex verticillata was the great mistake in the border planting. This species was totally out of its habitat, and there was no way we could recreate the habitat. A planting of this species situated on a shaded slope leading down to an inlet is successful, however. *Ilex verticillata* is the perfect example of shrubs often recommended for wildlife plantings but that cannot benefit the wildlife in Central Park since they rarely survive in the Park's harsh environment.

There have been other planting successes and failures throughout the Park that are worth reporting. Central Park was built on rocky, barren land; therefore, shallow soil is a common problem. *Myrica pensylvanica* and *Elaeagnus umbellata* seem to take this limitation in stride, thriving on rocky, fully exposed sites and yet tolerant of light shade. Both species contribute to the success of the wildlife planting at The Point, a rocky peninsula jutting out into the 72nd Street lake. A planting of *Rosa rugosa* at the tip of the peninsula provides a thicket of cover for wildlife and a great deal of pleasure for birdwatchers and other naturalists. It is extremely vigorous and flowers as profusely as it would in a seaside environment.

At the same site, *Cornus racemosa* has proved successful, tolerating the dryness and exposure of the rocky site far better than *Cornus sericea*. Two other species used at The Point, and which we were hoping to use frequently in the Park, are *Magnolia virginiana* and *Rhus typhina*. Unfortunately, they were never given a chance to survive or to fail: *Magnolia virginiana*, with its attractive foliage and flowers, was repeatedly vandalized; *Rhus typhina* provided sticks and fishing poles until the planting was depleted.

Aronia arbutifolia and *Vaccinium corymbosum* are also used at The Point and other sites to attract wildlife. While not a vigorous grower, *Vaccinium corymbosum* is tolerant of exposed sites and dry periods and can adapt to disturbance by Park users. The site has proved too dry for *Aronia arbutifolia*; nonetheless, we will try the species again where soil conditions are more favorable.

We have had success with *Berberis* ×*mentorensis*, the mentor barberry, which, when taken care of, is as adaptable as the more weedy *Berberis thunbergii*. While we have often used the mentor barberry to control circulation patterns, we are finding that the shrublike 'Seafoam' and 'Fairy' roses are even more effective in controlling soil erosion by controlling foot traffic. Interplanted on a totally exposed slope in the Park, both the 'Seafoam' and 'Fairy' have grown in a rambling and rampant fashion, forming thick, impenetrable mounds that are covered with flowers for two to three months. The landscape looks far softer and more agreeable to the visitor than it does when barberry is used. The negative connotation of a barrier planting is eclipsed by the aesthetic pleasure the roses provide. The vigorous growth of the roses creates a microclimate where the soil surface is shaded, affording them a cool, moist root run, even in the exposed area. Insect damage has not been a noticeable problem. The floral display is in accord with Olmsted and Vaux's philosophy: they wanted flowers in the Park to be seen, not as individuals but amidst masses of lush foliage and vigorous growth.

In 1983 and in the spring of 1984, we added additional species to Park plantings. Among them were *Fothergilla gardenii*, *Enkianthus campanulatus*, *Calycanthus floridus*, *Rosa nitida*, *Rosa wichuraiana*, *Hydrangea quercifolia*, *Rhus aromatica*, and *Cotinus coggygria*. We also added several species of native azalea: *Rhododendron vaseyi*, *R. schlippenbachii*, *R. bakeri*, *R.* 'Janet Blair', *R. prunifolium*, and *R. nudiflorum*. By 1986 or 1987, they will have shown their tolerance, or lack of it, of conditions in the Park. Some of these species are "fragile," but we hope that if particular species are used with plants that already have proven their vigor, the new species will receive some protection while they are becoming established.

We also realize that many species of plants that are not yet used in Central Park might be successful on "green islands" within all urban environments. While at some locations we can use five to ten of a species, we are more likely to use fifty to five hundred. The availability of particular plant species often limits their use. At specific sites where protection and maintenance are adequate, we plant bare-rooted material. Its use increases the range of species and actually eliminates a characteristic disadvantage of planting in urban soils, which is the problem of interface between the nursery soil of the root ball and the built soil of the urban greenspace. Species that are more "opportunistic" when they are planted with bare rather than balled and burlapped roots will brighten the future of urban park plantings.

Two years after the initial planting, the border planting at the Park's perimeter was achieving its design intent. Wood-chip mulching was still necessary, because leaves continued to be blown off the slope. However, this maintenance task was continually reduced as the understory planting grew and covered the exposed areas on the slope.

While the forest now growing at the edge of Central Park does not block out the harsh urban environment, it is the most effective antidote to it.

Evaluation

We have devised a method of evaluating plants. The evaluation has two objectives:

- To relate plant survival and growth to specific site and environmental characteristics, and
- To determine whether particular plant species are fulfilling the purpose for which they were planted.

To avoid drawing premature conclusions, we have limited our evaluation to plantings that are at least two years old. We have organized our data collection to measure the following four variables:

- The adaptability of given species to existing site characteristics (slope, fertility, drainage, soil depth and texture, exposure, reflected heat, competing vegetation, ground cover, public use),
- Biological condition (resistance to drought, resistance to flooding, pH, salt tolerance, transplantability, percentage of deadwood, growth rate),
- Ornamental value (foliage condition each season, period and persistence of flowers and fruits, growth habit, freedom from serious insects and diseases), and
- Maintenance responsibilities and their frequency (irrigation, pruning, mulching, fertilization, monitoring for pests and diseases, replacement).

A great deal of basic information about the plant materials is collected before any information specific to the site is garnered from field visits. The following data are recorded: planting location and date; height and spread; when planted; native habitat; nursery source; kind of stock (bare root, balled and burlapped, or container); design function; and the plant's historic value to the Park. All data are entered during the winter months. Scheduled on-site visits are made to determine percentage of deadwood (entered mid-July), and growth rate (entered mid-August). Weekly visits are made during the appropriate season to determine the degree and persistence of flowers and fruit, and the condition of leaves and twigs.

Once all observations are computerized, we will be able to retrieve information that will greatly influence our selection of plants. We will know what to expect when a certain species is planted in a specific environment for a well-defined purpose or design function.

Reference

Frederick Law Olmsted Association and Central Park Community Fund. *Central Park Plant List and Map Index of 1873.* New York: The Frederick Law Olmsted Association and the Central Park Community Fund, 1979.

Acknowledgment

The author thanks landscape architects Marianne Cramer and Judith Heintz for invaluable historical background information.

Geraldine Weinstein, director of horticulture for the New York City Department of Parks and Recreation, was director of horticulture for Central Park from 1980 to 1984. She has recently been awarded a prestigious Loeb Fellowship by the Graduate School of Design of Harvard University.

Chemicals That Regulate Plants

John W. Einset

Five key plant hormones have commercially valuable uses in horticulture, and there is promise of more to come

Plants, like other living things, have complex internal mechanisms through which they coordinate their growth and respond effectively to changes in their surroundings. A fundamental concept of botany states that fluctuations in the amounts of a few key chemicals known as plant hormones, or "phytohormones," regulate practically every aspect of plants' functioning. Since the discovery of the first phytohormone nearly fifty years ago, botanists have learned much about these internal regulators, and the knowledge they have gained has been exploited successfully to develop practical uses for phytohormones in horticulture. Without question, research on phytohormones has already paid for itself. Moreover, scientists working on phytohormones believe that the prospects of finding new ways of manipulating plants with these chemicals are especially encouraging.

The Five Kinds of Phytohormones

Five distinct categories of phytohormones are recognized, each of which has characteristic molecular structures and physiological roles in plants: auxin, ethylene, cytokinin, gibberellin, and abscisic acid.

Auxin, the first phytohormone discovered, is probably the best understood of them all. The major form of auxin in plants is the chemical indole-3-acetic acid (IAA), which has been implicated in a variety of phenomena, including plant "architecture," the bending response to light, flower formation, leaf and fruit drop, and fruit maturation.

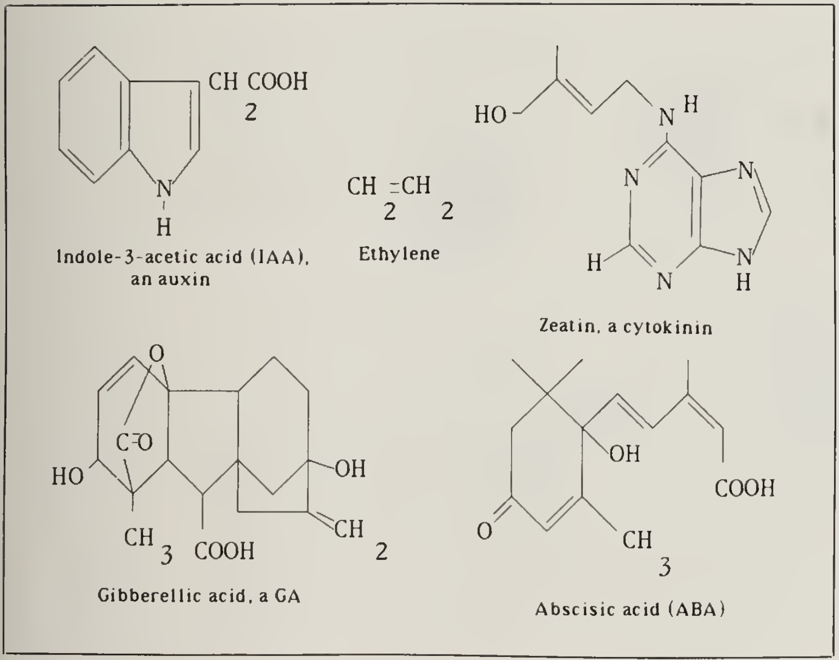
Ethylene, structurally the simplest hormone found in any living thing, regulates fruit drop, flowering, fruit ripening, and the death (senescence) of plant parts. After auxin, ethylene is the most important phytohormone in commercial practice.

The phytohormone cytokinin, on the other hand, currently is of limited practical use, even though tissue culture would be impossible without it. Because of its crucial role in tissue culture, cytokinin undoubtedly will assume increasing importance as advances are made in biotechnology. Cytokinin controls seed germination, plant architecture, the movement of gases between the interior of leaves and the atmosphere, fruit development, senescence, and fruit drop.

Gibberellin (GA), of which over sixty different chemical variants are known, regulates seed germination, stem growth, flowering, and fruit development. Many so-called "dwarf," or stunted, plants are actually defective in their abilities to produce GA.

Abscisic acid (ABA), the last phytohormone to be discovered, is responsible for seed dormancy. It also regulates the growth of roots and the exchange of gases between leaves and the atmosphere. To date, there are no important practical applications for abscisic acid, although the prospects are good that it will become a valuable chemical for increasing the capacity of plants to withstand drought, since it influences the amount of water that plants lose from their leaves.

In spite of all we know about phytohormones, an obvious question comes to mind: "Are there



Representative chemical structures of the five currently known classes of plant hormones. Prospects for discovering additional kinds are considered to be especially good.

other kinds of phytohormones yet to be discovered?" The answer almost certainly is, "Yes." After all, over fifty different hormones are known among animals; it stands to reason, then, that plants have more than just five different hormone systems. In fact, there is evidence that the actual number of phytohormones is at least twice as large.

Horticultural Applications of Phytohormones

By far the greatest commercial use of phytohormones is as weed killers, that is, as herbicides. A practice begun in the 1930s, the use of excess doses of auxin as herbicidal treatments has become a multimillion-dollar industry. In the United States alone, over fifty million pounds of the synthetic auxin 2,4-dichlorophenoxyacetic acid (2,4-D) are applied to millions of acres of agricultural land, as well as to golf courses, public parks, and lawns. An important aspect of this technology is the selectivity of the herbicidal effect: at the levels of auxin applied, dicotyledonous plants ("dicots"), such as dandelions, are killed, but monocotyledonous plants ("monocots"), such as grasses, are left unharmed.

While the use of phytohormones as herbicides might be considered a drastic measure because it involves excessive concentrations of auxin, most practical methods involve subtle alterations in the levels of hormones *inside* plants. An example is the regulation of seed germination with GA.

When a dry seed of a grain such as corn, barley, or oats is soaked in water, the seed produces enzymes that break down the protein and starch that are stored in the seed into their component "building blocks," which nourish the young seedling during the early stages of its growth. Obviously, the coordination of protein and starch breakdown with embryo growth and seedling development is of crucial importance. This is where

Cuttings of *Syringa* obtained through tissue culture and stimulated to produce roots by applying auxin. Photograph by the author.

GA plays a role. For example, one of the first events associated with water uptake by the seed ("imbibition") is the production of GA in the embryo. The GA produced diffuses from the embryo to a layer of cells immediately beneath the seed coat, where it activates the genes for enzymes that release stored reserve nutrients.

In the production of malt, which is popular as an additive for milk and is used to make beer, barley or oat grains are allowed to germinate only to the stage at which most of the starch in them has been converted to soluble sugar. At this point, development of the seedling is stopped by a heat treatment, and the resulting malt is ground to a powder. Sometimes, the grain is treated with GA during the imbibition period. This practice stimulates the breakdown of starch and ensures uniform malting. Several beers from Australia are produced from GA-treated barley.

One of the earliest applications of auxin in horticulture was to stimulate the formation of roots on cuttings. Nowadays, auxin in either liquid or powder formulations can be purchased at most garden-supply stores; it can be used at home to induce roots to grow on cuttings of most common horticultural plants. Essentially the same procedure is used by nurseries for propagating plants, especially when large numbers of identical individuals are needed.

In the last fifteen years, tissue culture has become increasingly important as a tool for propagating plants. (See "Biotechnology at the Arnold Arboretum" in the Summer 1984 issue of *Arnoldia.*) Known as "micropropagation," the usual method involves "shoot multiplication" in a nutrient medium, followed by the auxin-induced rooting of cuttings. After a shoot tip from a plant has been decontaminated, it is transferred to tissue-culture medium containing enough cytokinin to sustain growth and overcome apical dominance in elongating shoots. The result of this manipulation is the production of several, simultaneously growing shoot axes starting from only one tip, that is, shoot multiplication. Individual shoots are then used for further shoot multiplication in the next tissue-culture passage, or they are used as cuttings and rooted with an auxin treatment. Theoretically, it is feasible to produce over a million plants from a single shoot tip through tissue-culture technology in just one year.

New Applications

According to the major scientific hypothesis relating phytohormones to the architecture of plants, shoot growth is a result of interactions between auxin, cytokinin, and GA. Auxin produced by the growing tip inhibits lateral buds in the axils of leaves, a phenomenon known as apical dominance that, in extreme cases, results in an unbranched (or "monopodial") axis. Cytokinin, on the other hand, counteracts auxin, so that shoot systems in which cytokinin is produced at a high rate consist of several, simultaneously growing brances, a situation called "sympodial" growth. Branching, or its absence, therefore, is a consequence of the auxin–cytokinin balance. By contrast, the length of internodes (stem elongation) is regulated by GA.

Theoretically, the architecture of cultivated plants could be manipulated by altering the levels of any one of the three critical phytohormones. The common practice of nipping buds on houseplants, for example, effectively removes the source of auxin responsible for apical dominance. The result of this treatment is sympodial growth due to the liberation of lateral buds that the auxin produced in the tips of the stems had prevented from developing. Liberation of the lateral buds causes a bush-like, branched architecture. So-called growth retardants, many of which inhibit the production of GA, shorten the internodes of treated plants, resulting in dwarfed, compact architecture. Two examples of growth retardants are cyclocel and ancymidol.

The use of growth retardants has increased substantially in the last few years. Because they inhibit the elongation of stems, growth retardants reduce the need for expensive tree-trimming operations. As a matter of fact, several utility companies currently use growth retardants as a cost-saving measure along streets with aboveground power lines. Growth retardants are also applied to a major variety of wheat in West Germany that has a tendency to lodge (blow over) in high winds. They are also used on lawns to decrease the need for periodic mowing.

Sometimes, however, it becomes necessary to stimulate the growth of a lawn. Two days before the beginning of a national golf tournament, for example, the grounds crew mistakenly mowed an area designated for high grass (the "rough"). GA was put on the affected area, growth sped up, and the rough was restored just in time for the start of play.

Leaf drop, or abscission, is regulated by the relative concentrations of auxin and ethylene in the abscission zone. Ethylene tends to stimulate the process, while auxin inhibits it. In certain instances, cytokinin, GA, and ABA may also exert some control, although their effects vary widely according to the species of plant involved.

Probably the most important commercial use of phytohormones for defoliation involves cotton production. In normal practice, plants are sprayed a few days before harvest with an abscission stimulator (for example, an ethylene-generating chemical) that causes the leaves to drop but does not affect the cotton bolls, which can be harvested with a mechanical picker without harvesting leaves as well. Obviously, the savings that result from using phytohormones in cotton technology are substantial.

Other practical uses of phytohormone defoliants have been controversial. During the late 1960s in Vietnam, for example, phytohormones were sprayed from U.S. military airplanes to cause the leaves of rain-forest plants to fall off. According to official policy, this was done as a temporary, tactical measure, but the repeated treatments killed most major species of trees in the rain forests. The long-range consequences of this practice, both in terms of human health and the future of the Vietnamese ecosystem, are still being studied.

For years, chemicals have been applied to pineapple plants to stimulate flowering and, thereby, to synchronize fruit development and maturation. The value of this technology is realized in more efficient harvesting of ripe pineapples. When the practice was begun in the 1930s, smoke from fires was utilized. Today, an ethylene-generating compound known as ethephon is sprayed on plants.

Phytohormones also can be used to stimulate flowering in several other economically important plants. Fruit trees such as apple, pear, and peach are treated with chemicals to increase the number of flowers. During the commercial production of seeds for biennials such as carrot, beet, and cabbage, GA is used to cause flowering in the first year. Similarly, GA can shorten the time it takes for conifers to form cones, speeding up breeding programs with these plants.

In some instances, it is advantageous to inhibit flowering. An especially dramatic example of this involves sugarcane. Chemicals are routinely utilized to prevent sugarcane from flowering during the time it is accumulating sugar. It is estimated that yield increases averaging 1.3 tons per acre are obtained in Hawaii as a result of this practice. Inhibitors of flower formation also are used to overcome "alternate bearing" in tree crops, the alternation of heavy ("on" years) and low ("off" years) flowering, with corresponding effects of fruit production. In the extreme case of mandarin oranges, alternate bearing causes fluctuations in fruit yield ranging from forty to zero boxes per tree in successive years. GA is used in Spain and Australia to reduce flower formation during "on" years. Similarly, in the United States, apple flowers are thinned during "on" years with an auxin treatment.

Phytohormones also affect cut flowers. As soon as a flower is removed from a plant, the natural process of senescence speeds up, in large part through the agency of the phytohormone ethylene. Obviously, if flower senescence is to be delayed or prevented, the logical strategy is to counteract ethylene's effect. Various methods have already been devised for just this purpose, in fact, and some of them may have economic potential in the cut-flower trade. One way of extending the life of cut flowers is to refrigerate them, slowing down the metabolic reactions that result in senescence. A second method involves the treatment of flowers with anti-ethylene compounds. Silver ion in the form of a silver nitrate solution, for example, inhibits the action of ethylene. Or, senescence can be retarded with inhibitors that block specific steps in the chemical pathway that leads to the production of ethylene by a plant.

Phytohormones are used extensively to regulate fruits, from their earliest stages of development through harvest, and even during postharvest storage. In fact, the major commercial use of GA in the United States involves seedless table grapes. By treating young grape clusters with GA, one can reduce the number of berries per bunch, but obtain larger and juicier individual fruits. There is no question that the GA-treated product is superior to the untreated one. In this case, phytohormone technology can boast a true success story. (See the inside back cover.)

By contrast, phytohormone technology applied to tomatoes yields a definitely inferior product. Nonetheless, tomatoes are routinely harvested in the United States before they are mature, often with mechanical picking devices. The green fruits are then treated with ethylene to simulate ripening. The rationale for using this technology is that savings in the cost of harvesting outweigh the extra value of vine-ripened tomatoes. Moreover, it is argued, added ethylene only accelerates a process—ripening—that normally is under ethylene's control. Unfortunately, this latter assertion is a ridiculous oversimplification of what is involved. After all, who hasn't bought a "red" tomato that actually tasted "green"?

Because of its role in abscission, ethylene can be used effectively when fruits are harvested mechanically. In commercial practice, plants are sprayed with ethephon or some other ethylene-generating chemical a few days before harvest.

This treatment initiates formation of abscission zones that, in turn, loosen the fruits. Harvest then becomes a simple process of agitation—either shaking of the stem or a blast of air, followed by collection of the detached fruits. Ethylene-aided mechanical harvesting is a common procedure for cherries, blueberries, grapes, and oranges.

Sometimes, fruit abscission needs to be prevented. For example, when grapefruits and oranges reach maturity, they naturally drop from the tree as a result of abscission. To prevent this process and its associated economic losses, trees can be sprayed with auxin or with a mixture of auxin and GA when the fruits are quite young. The combination of the two hormones accomplishes two purposes: auxin keeps mature fruits on the tree, GA keeps them fresh.

Once a fruit has been harvested, senescence proceeds rapidly. (Senescence also occurs when flowers are removed.) To prevent this, fruits are usually stored at low temperatures to slow down their metabolism, and they are kept in a controlled atmosphere. Often, the amount of carbon dioxide in the air is artificially increased in storage because carbon dioxide tends to counteract ethylene's stimulatory effect on senescence, through a mechanism called "competitive inhibition."

Promising Areas for Applications Research

Other strategies currently are being used to control plants with phytohormones, but the examples given here illustrate the major strategies in use. Much already has been accomplished, with considerable economic impact, but much more could be done if the appropriate technology were developed.

For instance, it is conceivable that a plant's own defense systems for preventing diseases caused by viruses and microorganisms could be accentuated with chemicals. One class of compounds responsible for disease resistance (phytoalexins) has already been identified, and research currently is under way on phytohormones to stimulate the production of phytoalexins. If this research succeeds, we might be able to improve a plant's response to disease through the use of chemicals.

A second promising area involves so-called "bioregulators," which are chemicals that stimulate plants to make valuable products. For example, ethephon is used commercially to increase the production of rubber by *Hevea*. Another group of bioregulators is now being evaluated for their effects on the production of terpenoids by plants.

Of course, the greatest potential impact of phytohormones involves "biotechnology," the concerted application of different scientific disciplines to plant genetics. While most accounts of biotechnology emphasize the contribution of DNA biochemistry, biotechnology would not be feasible without the use of phytohormones, especially of cytokinin, to produce whole plants with new characteristics starting from single, genetically altered cells. Even today, phytohormones play a crucial role when tissue culture is used for the rapid, clonal propagation of plants that have superior characteristics, and for the production of plants, such as strawberries, that are free of virus and fungal infections.

Tissue culture, in spite of its performance, is still a relatively new technique. The common method for micropropagation takes advantage of the established role of cytokinin as a shoot-growth regulator and of the fact that shoot explants from many species can be grown on a medium consisting of basal nutrients plus cytokinin. During the last few years at the Arnold Arboretum, research has been conducted to determine whether this same method can be applied to woody plants in general. While this research is still under way, it has already made clear that microprogation would be feasible with several groups of woody plants that are not now being exploited. For example, nearly half of the thirty-five families studied to date respond to cytokinin treatments in tissue cultures even though current micropropagation work with woody plants focuses on only two families—the

Rosaceae and the Ericaceae. On the other hand, it is also apparent that this technology will not work for all woody species. Obviously, we do not fully understand shoot growth in several species.

Before cytokinin was known, micropropagation of plants was not possible. Nonetheless, basic research on the internal control of shoot growth led not only to the discovery of cytokinin, but to a new and important practical use for phytohormones. Looking to the future, but reflecting also on fifty years of successful work with chemicals that regulate plants, we can feel almost certain that similar successes will occur. As we learn about phytohormones and discover new kinds, our ability to regulate plants will also increase. As so often happens, botany and horticulture will complement each other.

John W. Einset, a staff member of the Arnold Arboretum, is associate professor of biology in Harvard University. His article on biotechnology at the Arnold Arboretum appeared in the Summer 1984 issue of Arnoldia. *With the present article Professor Einset inaugurates a new column for* Arnoldia. *Called "Botany: The State of the Art," the column will deal with practical application of botanical research to horticulture.*

BOOKS

Garden Design: History, Principles, Elements, Practice, by William Lake Douglas, Susan R. Frey, Norman K. Johnson, Susan Littlefield, and Michael Van Valkenburgh. Derek Fell, principal photographer. New York: John Wiley and Sons, 1984. 224 pages. $35.00.

B. JUNE HUTCHINSON

This multiple-author book on garden design is introduced by John Brookes, as well-known landscape designer and garden writer from Britain. Brookes observes that we "dream up a garden to escape the rigors of our society," and, whether or not escapism is the reason people garden, it seems true that gardeners are dreamers. When the earth is frozen and winter snows end the growing season, the serious gardener simply turns to his plant books and catalogs and dreams his visions of the greater glories of the next year. He reads, plans, and anticipates until he can dig in the soil again. *Garden Design* will enrich winter dreaming.

A group of garden designers and writers put this book together in cooperation with the Publication Board of the American Society of Landscape Architects. Hundreds of color photographs, many of them the work of talented garden photographer Derek Fell, illustrate various garden styles ("The Parterre," "The Outdoor Room," "The Country Cottage," "The Oriental Style," and "The Wild Garden") and the varieties of built elements and embellishments that can be used to implement those styles (paving, turf and ground covers, gates and windows, and so on). From its dust jacket to the final photographs, this book is a rich source of ideas.

The first of *Garden Design*'s six chapters is a concise review of garden history. It gives the novice an organized and clearly written overview but will not disappoint the more knowledgeable garden-history reader. The latter will appreciate the author's balanced assessment of landscape gardening. Proper emphasis is given to the enormous impact of nineteenth-century plant collecting on garden design. The author (William Lake Douglas) succeeds in conveying to the reader the vitality and energy of the Victorian who tended his garden during the period when America's

The gardens at Vaux-le-Vicomte, France, considered one of the greatest achievements in the French landscape style. It was designed by André le Nôtre in the seventeenth century. Photograph by Christopher Little. Used with the permission of Quarto Marketing, Ltd.

newly emerged middle class was embracing the idea of conscious garden design. Appropriate attention is also given to Andrew Jackson Downing's important role in American landscape design. Downing's widely popular books were the first publications in this country to emphasize garden design based on aesthetic principles and the concept of unity of house and grounds.

The essence of the three major chapters of the book ("Discovering Your Style," "A Sense of Place," and "Elements of the Garden") is simply stated: determine what you want in your garden and adapt it to the space you own by using the appropriate design elements. This is, needless to say, not so easily accomplished, and *Garden Design* will not take the place of professional help, nor will it guide the do-it-yourself gardener through the planning and installation process. However, instructions of creative design ideas accompanied by intelligent and precise captions can help the gardener take the first step toward understanding some general design principles and defining his own personal tastes. This book offers that kind of help in abundance.

Chapter Five, a showcase for the work of fifteen garden designers from the United States and four other countries, is a combination of text and photographs. Both the reader and the designers whose work is dealt with might have been better served if the two pages allotted to each designer had been devoted exclusively to photographs of his work, along with carefully crafted captions telling the reader what the designer's intention was and how he achieved the effects he sought through his choice of design elements. As it is, the two pages are a mixture of biography, direct quotes, and the author's assessment of the designer's work. Photographs allow a reader to see, and judge, for himself.

The last chapter, entitled "Garden Wisdom," is said to be a "necessary reference on all aspects of implementing the garden's plan," but it is much too short to be a useful reference. It does, however, impart some marvelous bits of advice that are essential to successful gardening. Take the first sentence of the last chapter, for instance: "The better part of garden wisdom has to do with patience. You simply cannot make a garden in a hurry." Garden dreamers understand patience. They will also understand and appreciate the rich ideas in *Garden Design*.

B. June Hutchinson is a writer and a landscape designer. Her article on the umbrella pine was published in the Winter 1983–84 issue of Arnoldia.

Plants that Merit Attention: Volume I—Trees, edited by Janet M. Poor. Portland, Oregon: Timber Press, 1984. 352 pages, 429 color plates. $44.95.

RAY ANGELO

Most illustrated tree manuals are guides to the identification of the trees that grow in a given geographic area. This handsome volume is different. It brings to the fore a number of neglected species, varieties, and hybrids of trees that would be worthy additions to parks and gardens, offering a generous selection of 143 taxa. Most of the taxa it treats originated in eastern Asia (60 taxa), North America (47 taxa), or the Europe–Mediterranean area (17 taxa). This selection reflects the target area for the manual, which is North America. Their visual appeal, seasonal interest, and tolerance of one or more environmental stresses were the bases for including taxa that are not often seen in horticultural landscapes.

This book will be a useful aid in selecting appropriate species and varieties of trees for given sites in yards, gardens, and parks. To consult it is to opt for novelty. The geographic location of a site will immediately eliminate a number of taxa from consideration. One appendix in this volume groups species and varieties according to their cold-hardiness. Only *Larix decidua* is hardy in USDA Zone 2 (northern Quebec, northern Ontario, etc.), for example, while ten species are hardy in Zone 3 (northern Minnesota, northern

Maine, etc.). Additional appendixes list the species that do best in sites with special soil-moisture conditions (moist to wet, arid, seacoast) or shade. Still other appendixes list the species that are more or less tolerant of environmental stress and those that are resistant to pests and diseases (although the reader must refer to the text to find out *which* stresses, pests, and diseases).

Once the limitations of a site have been dealt with, the subjective preferences of the reader will narrow the choice further. Appendixes listing species on the basis of flower color, fragrance, conspicuous autumn foliage, and whether they are deciduous, coniferous, or broad-leaved evergreen will assist the reader who seeks a particular quality in the candidate tree.

At this point the reader will want to consult the body of the book, where entries are arranged alphabetically by scientific name. The color photographs are, perhaps, the most striking feature of the book, which as a whole is of a high quality. Albert W. Bussewitz, whose photographic and interpretive work at the Arnold Arboretum is well-known, contributed many excellent photographs. Of particular note for their beauty are his close-ups of *Asimina triloba*, *Davidia involucrata*, *Halesia monticola*, and *Sciadopitys verticillata.* Although in most instances the three photographs provided for each taxon show its habit and distinctive attractions, the same feature is occasionally illustrated more than once (for example, *Gordonia lasianthus*, *Ilex* spp., *Oxydendrum arboreum*, and *Tabebuia chrysotricha*). For some taxa there is no close-up one could use to discern their distinguishing features (for example, *Prunus* 'Okame'). The photographs alone may be enough for making a final choice, but, if not, the text is available.

Many botanists, horticulturists, and nurserymen contributed to the text, among them Stephen A. Spongberg and Gary L. Koller of the Arnold Arboretum staff. Since this is not an identification manual, keys to species are not provided or appropriate. Comparisons with closely related species are almost entirely with reference to their landscape value. The text is divided into three categories for each entry: description, culture, and landscape value.

The descriptive material is not intended to separate the included species from related species, which would be done routinely in a taxonomic work, but rather to highlight features of interest and to provide basic information about each taxon: its size, habit, leaf size, fall color, flower color and size, fruit character and size, and bark aspect. An illustrated glossary in the Introduction defines botanical terms, most of which are used in the text. Terms relating to ovary position are not used in the flower descriptions, however, while other terms, such as "rotate," "globose," "glaucescent," and "stomata," are used in the text but not defined.

The section on culture gives more details about soil, light, and moisture requirements and on disease and insect problems that are merely touched on in the appendixes. This section also provides notes on transplanting and propagation that may require elaboration from a nurseryman once a tree has been chosen. For example, the note on transplanting *Sapium sebiferum* is simply, "Easy when young."

If at this point the reader is still weighing evidence before making a decision, the landscape-value paragraph might suffice to tip the balance. This portion of the entry certainly makes the most interesting reading. Noteworthy facts about the species (for example, *Prunus subhirtella* 'Autumnalis'—"One of the earliest Oriental cherries to bloom"), comparison with related species, and practical or historical notes (*Michelia doltsopa*—"A valuable timber tree in the Himalayas"; *Roystonea regia*—"Named for General Roy Stone") make up this section.

As a last resort, one might have to examine a living specimen before making up one's mind. To this end, the entry for each species includes a list of the arboreta, botanical gardens, and notable parks and gardens where one could observe the species. Useful as such a list is, many readers will find it impractical to visit most of the worthy institutions listed. In particular, the list could properly omit foreign arboreta and gardens, such as the Royal Botanic Gardens, Kew, München Botanischer Garten, and Forest Parks–Ibaraki, Japan, which most North Americans could not readily reach.

Assuming that the reader has at last selected a species of tree for the site, the next question is where to obtain it. This book addresses the issue by listing nurseries across the continent (including their addresses and, for most, their telephone numbers) that carry one or more of the included species. Making this list even more valuable is an appendix that lists the species and varieties included and the code letters of each nursery that carries the particular species or variety.

Through this impressive volume, even someone who is not particularly seeking a tree to enhance a yard or a city park will become acquainted with a wide variety of trees that deserve more appreciation than they receive at present. This is the first volume of a series that will include shrubs and herbaceous plants. If the future volumes maintain the standard of quality represented here, they should be well received.

Ray Angelo, curator of the New England Botanical Club's vascular plant collections, is the author of Concord Area Trees *(1976) and* Concord Area Shrubs *(1978).*

The Book of Edible Nuts, by Frederick Rosengarten, Jr. New York: Walker and Company. 412 pages. $35.00.

GEORGE STAPLES

I have eagerly awaited Frederick Rosengarten's *The Book of Edible Nuts,* since I had often referred my students in economic botany to his excellent *Book of Spices.* The wait for Rosengarten's newest book has been worthwhile; like the earlier volume, *The Book of Edible Nuts* will become a standard reference for economic botanists, horticulturists, home economists, and producers of edible nuts. The thoroughly researched and well written text will make it an enjoyable acquisition for anyone eager to learn more about nuts—their botanical origins, historical uses, and current commercial production.

This is not a "how-to-do-it" book on the home cultivation of edible nuts. Given the diverse readership the book will attract, this limitation seems sensible. While the biology of each of the twelve major and thirty lesser-known species is discussed in general terms, there are no specific horticultural instructions in the text. The bibliography includes the titles of agricultural bulletins and other sources of information on growing edible nuts. Interested readers will have to scan the entire bibliography to locate these titles; cross-references from the text to the bibliography would have made this information easier to locate.

But the book offers a wealth of other fascinating information. Beginning with the accepted scientific name and a list of common names in eleven languages, each of the twelve major nuts is discussed with respect to its historical use, botanical status, and current commercial production. Each discussion concludes with selected recipes. The minor nuts are treated in less detail, but afford an appreciation of the diversity of nut crops worldwide and stimulate one's curiosity to learn more about such exotic species as the pili and the jojoba.

I found the descriptions of the historical use of nuts from different cultures and time periods fascinating; the breadth of this treatment alone attests to the amount of research the author put into his work. This section interweaves medicinal, artistic, literary, and archaeological information into a highly readable narrative. The botanical accounts are equally interesting, while the commercial-production figures are current and indicate the economic importance of nuts at the present time.

I confess to having felt some misgivings as I read the recipes offered for the various nuts, however; they presented a sterile uniformity reminiscent of a home economics text. I consulted the recipe acknowledgments and confirmed my suspicions. No family heirlooms mentioned here: all the recipes were contributed by commercial nut-production and marketing organizations. The reader with gastronomic inclinations will miss the homey touch of Polly's Perfect Pecan Pie or the challenge of a new interpretation of Gong Bao Ji (Kung Pao Chicken). I felt that the recipes were the book's weakest point.

The profusion of illustrations is a visual feast that compensates for the blandness of the recipes. Taken from diverse botanical, historical, and artistic sources, the black-and-while photographs correlate closely with every aspect of the text. Inclusion of international postal stamps featuring nut motifs adds an unusual twist, and brings philatelists within the scope of the book's readership. The endpapers are the only colored photos in the book. The inclusion of more colored illustrations would doubtless have increased the book's cost considerably.

Two minor practical shortcomings bear passing mention. Verbal descriptions of the historical place of origin and modern areas of cultivation for each species of nut presuppose that the reader is familiar with geography. Regretfully, many college undergraduates today lack sufficient command of this subject to relate place names to a world map. For those who would use this volume as a reference in teaching economic botany, inclusion of distribution maps would have been a welcome addition. The adventuresome might also wish for a list of mail-order sources of the exotic and lesser-known nuts, so as to order some for consumption at home.

Perhaps these small improvements will appear in future editions of *The Book of Edible Nuts.* Better still, Mr. Rosengarten might keep them in mind for his next book. Whatever his choice of subject, the new work will be worth waiting for.

George Staples is a graduate student in the Department of Organismic and Evolutionary Biology of Harvard University.

Coming in *Arnoldia*

From a watercolor by Alice Tangerini, Smithsonian Institution

The inflorescence and fruits of flowering dogwood (*Cornus florida* L.), top, and of kousa (*Cornus kousa* Hance), bottom. In the fall 1985 issue of *Arnoldia*, Richard H. Eyde will explain why kousa has compound fruits and flowering dogwood does not.

The Arnold Arboretum of Harvard University, a non-profit institution, is a center for international botanical research. The living collections are maintained as part of the Boston park system. The Arboretum is supported by income from its own endowment and by its members, the Friends of the Arnold Arboretum.

Summer 1985

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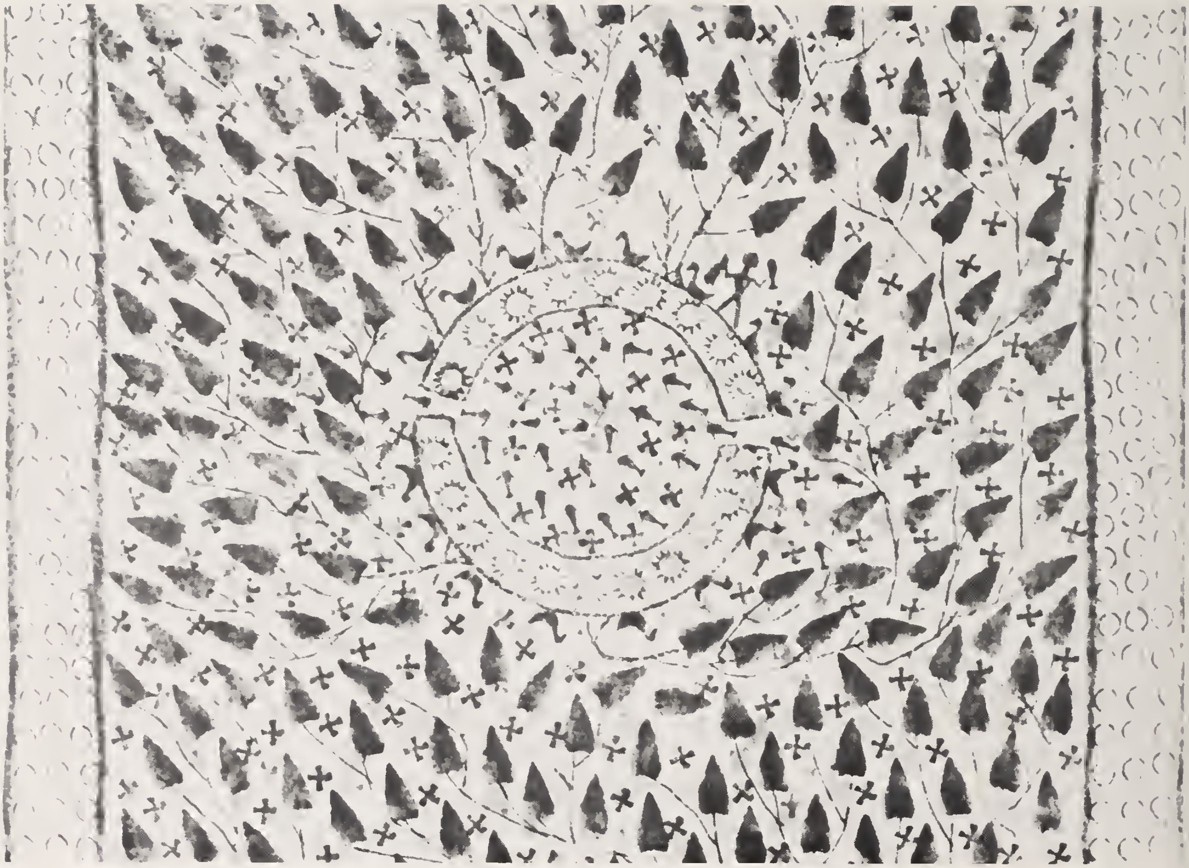

The Painted Landscape

A Toraja textile displayed at cultivation ceremonies embodies, in visual form, central messages of agrarian ceremonies. On the animated surface of this hand-painted and stamped cloth, an immense rice field is drawn. At the center of the field a circular fish-pond is portrayed. Small fish swim within the confines of the pond while a parade of ambling ducks circumambulate the outer edges of the pond walls; a boy grasps a fish in one hand and holds a woven fish-trap in the other, poised for plunging into the water. Throughout the painted rice-field, slender stalks of young rice are drawn, bending with the weight of full, triangular heads of rice. The tips of each stalk incline toward the right of the field, the direction of the rising sun, of affirmation, and the rituals of life.

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Front cover: On the coastal lowlands of Sulawesi, Indonesia, Toraja women and children rest beside bundles of harvested *padi* in the late afternoon sun at Pantilang Baru. (See page 2.) Photograph by Charles Zerner. *Opposite:* The sacred *sarita* cloth which the highland Toraja people of South Sulawesi, Indonesia, display during their rice-cultivation ceremonies. (See page 2.) Illustration used with permission of Joseph Fisher. *This page: Lygodium palmatum* (Bernh.) Sw., the climbing fern. Courtesy of Alice F. Tryon. (See page 27.) Drawing by Sarah B. Landry. *Inside back cover:* The tip of a twining frond of the climbing fern. (See page 27.) Photograph by Alice F. Tryon. *Back cover:* At the *medatu* [preplanting] ceremony, women prepare rice grains for planting by separating stalks from kernels. A ceremonial drum and rice barn are visible in the background. Stone Drum village, Sulawesi, Indonesia. (See page 2.) Photograph by Charles Zerner.

Page

Agricultural ceremonies stay the hand of entropy, transform mud into rice, and sustain an agrarian society in Southeast Asia

The Golden Waterworks: Toraja Rituals of the Wet-Rice Landscape

Charles Zerner

On the southwestern "petal" of Sulawesi, Indonesia's orchid-shaped island, the highland Toraja people have practiced the arts of wet-rice cultivation for centuries. For Toraja elders and ritual priests, the mystery of this landscape is "the transformation of mud into rice" or how, in our words, seeds become food-producing plants. For this Western observer, the central question was how, in a society without written script, tape recorders, or floppy disks, memories of this agrarian and ecological system were retained and conveyed to generations of preliterate farmers. I was to discover one answer in Toraja agricultural ceremonies.—C. Z.

The unmistakably elegant patterns of flowing water, monumental earthworks, and green plants of the wet-rice landscape are inscribed on the earth's surface throughout the Far East, from Japan and China to the Himalayas. Wet rice is cultivated in India and Sri Lanka in South Asia, and on Southeast Asia's mainland, in Burma, Thailand, Kampuchea, Laos, Vietnam, and Malaysia. The anonymous calligraphy of wet-rice farmers is impressed upon the environment of the Philippines and across portions of Indonesia's 3,000 islands, from Sumatra to Sulawesi. Scholars now believe that rice (*Oryza sativa*) was domesticated in Southeast Asia more than 7,000 years ago.

The structures of the wet-rice landscape, including irrigation systems and water-holding fields or terraces, are more than environmental inscriptions with an ancient lineage. Rice currently supplies half the diet of the world's population, accounting for more than 11 percent of the world's arable land. Before high-yielding rice varieties and commercially produced fertilizers were introduced in the 1960s, traditional techniques of water control and landscape management had provided Asian populations with food for more than 50 centuries, yielding between 1 and 1.5 tons of rice per hectare.

The cultivation of rice is based upon a fit between the structure and adaptive capacities of the rice plant, and the manmade landscape. Although most plants cannot grow in water-logged soils, rice, originally a swamp weed, prospers under such conditions. According to M. S. Swaminathan, Director General of the International Rice Research Institute in the Philippines, rice can grow in flooded fields because it has "an efficient passage from shoot to root," permitting the flow of essential oxygen.

The genius of wet-rice cultures—the creation and maintenance of a rice-producing landscape—is based on a web of cultural, social, and ecological relationships. Water from streams, springs, and rainfall is channeled to and through a network of interlinked fields. The environmental centerpiece of this system is the terrace: a field ringed by water-holding retaining walls, or bunds, made of rock or earth. Rice terraces are holding ponds through which the flow of water can be regulated, bathing growing plants in a broth of nutrients.

The wet-rice landscape is not an environmental "given," but a cultural construction which must

In preparation for planting, a rake is dragged across a field which has been turned with iron-tipped spades, To' Dama'. Photograph by T. Volkman.

be conveyed from generation to generation of cultivators. Without both a memory-like "vessel" in which environmental understandings and values are stored, and a means of communicating this knowledge, the structure of the wet-rice landscape would have been obliterated by the passage of time and the movements of water. Environmental "information," like the landscapes it informs, erodes without the integrating structures of memory. Without memory, individuals, cultures, and cultured landscapes lose their forms, dissolving into an entropic runoff of priceless information.

The Toraja Wet-Rice Landscape

For many of the 330,000 Toraja people who inhabit the mountainous hinterlands of South Sulawesi (formerly Celebes), Indonesia's orchid-shaped island, the arts of wet-rice cultivation are essential for daily life. Rice is cultivated in a score of varieties, including red, white, purple, and black, in irrigated terraces that lace the Toraja landscape.

Preparation of the land begins in September as men turn over clods of earth in fallow fields and repair terrace walls. In November, water from the mountain watershed is channeled into the majority of the terraces, and men break up the clods with their hands and feet; occasionally, to further prepare the soil, they use water buffalo to draw rakes across the bottom of water-filled terraces. At this time, seed is broadcast in nursery beds scattered throughout the landscape.

In January, seedlings are transplanted from the nursery beds to fields where the rice grows until it is "pregnant." When stalks of maturing rice bend with heavy fruits and the interior of each grain is hard rather than milky, it is time for harvest. Women and children from the surrounding region converge on the fields to begin the lively labor of severing rice from its stalk. Sheaves are piled in tawny stacks, sun-dried, and carried by men to villages on mountain slopes above the terraces.

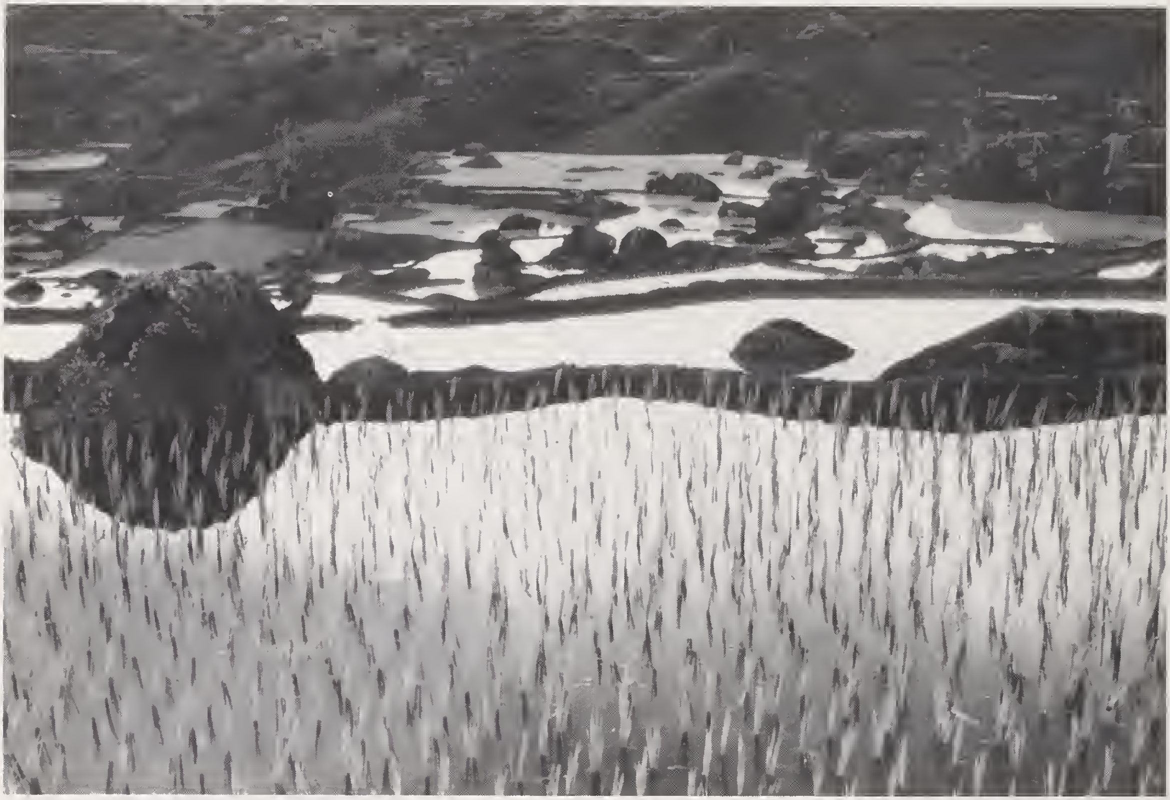
For centuries, the Toraja have practiced the arts of wet-rice cultivation. How have memories and images of landscape-making and watershed management been preserved? How has knowledge of rice cultivation been inscribed within the hearts and minds of each succeeding generation of highland farmers? Simple observation by each generation plays a major role in perpetuating this landscape, of course, but observation alone cannot account for the conservation of the wet-rice environment. The social organization of labor, the timing of cultivation practices, and the regulation of the irrigation system require some means of storing, integrating, and periodically representing information about the landscape.

Before the Dutch extended their control over South Sulawesi in 1906, the Toraja, like many other highland peoples of Southeast Asia, were a relatively isolated, preliterate people. *Aluk to Dolo*, or "Customs of the Ancestors," the Toraja indigenous religion, informed both ceremonial and everyday acts. Rice ritual or *aluk pare*, constituted a distinct sphere of ceremonial life. These affirmative ceremonies, associated with the rising sun and the growth of plants, were conducted by ritual specialists called *to minaa*, "The Wise Ones," and *indo' padang*, "Mothers of the Land," with a prodigious knowledge of myth, custom, and ceremonial speech. These masters of ceremonies inaugurate crucial phases in the calendar of cultivation.

Rituals of the Watershed

In September 1978, on the craggy slopes of Mount Sesean, towering 6,000 feet above a terraced landscape, five Toraja men make their way up a mountain ridge. They leave behind their village, Stone Drum, its carved rice granaries and fallow fields, and walk through a cool forest of dense bamboo. They climb past the last remaining

To Minaa [Wise One] Tandi Datu broadcasts rice seed into a nursery bed, Mount Sesean. Photograph by T. Volkman.



Newly transplanted rice seedlings, Mount Sesean. Photograph by T. Volkman.

houses and small vegetable gardens of onions, potatoes, and Arabica coffee trees, and emerge on a clear, forestless ridge where there are no signs of habitation or cultivation. In this windswept region of streams and fast-moving mists, they begin "Going Up the Mountain," the first preplanting ritual of the cultivation cycle, by making offerings.

Tandi Datu, a Wise One, and four Mothers of the Land carry offerings of palm wine, glutinous rice, and a small, squealing pig. The Mothers of the Land are leaders of cultivation ceremonies on Mount Sesean. As one prepares offering plates of banana leaf, and another sacrifices the baby pig, Tandi Datu chants, inviting the spirits of rice and the land to descend, to partake of the offerings, and to bless the coming planting of rice. The chant is called "Caring for the Mountain," and this is the first of a series of rituals that emphasize the importance of the natural watershed and the irrigation system. These ceremonies mark and bless the places where rainwater collects, mists condense, and springs well up from the ground. According to Tandi Datu, these rites of the watershed are "the foundation for rice planting."

After the ceremony high on Mount Sesean, the Mothers of the Land make offerings at sites on lower slopes, at springs, waterfalls, and individual rice fields. There, spirits are invited to partake of sticky rice steamed in coconut milk and roasted in green bamboo containers. As water is channeled into the rice terraces below, it is honored in ceremonial poems as part of the Toraja "family bamboo clump":

Different are the requests of the spring
Distinct are the desires of the waterfall
The wishes of cool pure water
—*To Minaa* Lumbaa of Buntu Tagari village

The complex of preplanting rites on Mount Sesean are called *medatu.* These ceremonies frame the landscape, marking places, or nodes of importance, in the natural and manmade environment. Following the ceremonies of the mountain, which honor places along the path of water to the rice fields, the second phase of *medatu* honors the journey of rice seed from the village granary to the nursery bed.

At Stone Drum, the Mothers of the Land gather crucial implements of cultivation: iron-tipped spades. These implements are employed to form and maintain the productive landscape, shaping terraces from mountain slopes, constructing terrace walls, and creating channels for the passage of water. A ritual practitioner lays the iron-tipped tools on a mat and sacrifices a baby chick in a ritual called "Cleaning the Water Diversion Canal." As the Wise One daubs iron tools with chick's blood, explicit connections are made between manmade instruments of cultivation, the water-procurement channels, and the prosperity of the wet-rice community. Like the borders of the mat of woven blue–green reeds on which the tools are set, this landscape ceremony focuses and frames the field of perception. Ritual compositions, like landscape paintings, create miniature fields: environmental fragments referring to larger landscapes of meaning and topography.

The Moral Compact of the Wet-Rice Cultivator

On the day seed is to be broadcast, Tandi Datu calls the spirits to his household. His words, couplets of imagaic speech, express his hopes for full fields of rice, growing "as thick as scallion leaves." Tandi Datu's prayer is more than a list of aspirations. It is an exchange: in return for "food and fruits wherever we will go," and a harvest "visible in a big pile," Tandi Datu tells the spirits "we will always worship you and deeply respect you." He utters a "firm promise," an oath that is "strong and walled with stone," "roofed with silver and walled with gold," to remember the spirits and perform their rituals, "a rule for life for mankind and all his creation." If the community of cultivators remembers the ritual performances, then "all ancestors" are awakened. In a state of heightened attention, the spirits, "guardians of the three stalks of *padi*," ensure the fruitful cultivation of rice. This is the moral compact of the Toraja cultivator and the spirits of the landscape:

Spirits whom I call and I invite with kindness
I make a corral for water buffalo which you enter and surrender rising and falling.

You will eat the rice we give to you with the side dishes
And after you eat, you will chew *kalosi* and *sirih* water in the mouth
You will spit far with pleasure.

You will accompany us in the working of the rice fields until we obtain the fruits
And you will make them multiply and become much during the night and the day.

We will always worship you and deeply respect you every time
To bless this *padi* and make it fertile
And the roots will never impede the growth/freedom
And the leaves will grow as thick as scallion leaves
And the fruits will be visible in a big pile, even that!
And all the rice fields will be ringed by heaps of *padi* that are even
And we will always be strengthened with this food and fruits wherever we will go.

And I will always promise with a firm promise the same as all these words
The promise which is strong and walled with stone that will protect
Roofed with silver and walled with gold.

And you, people we consider ancestors
And Puang Matua, the forger-spirit who gives a decree
A rule for life to mankind and all his creations
And will be made visible all kinds of forms
Awakened all ancestors
As guardians of the three stalks of *padi.*
—*To Minaa* Tandi Datu of Stone Drum village, Mount Sesean

Later that morning Tandi Datu, like many other farmers on the slopes of Mount Sesean, carries new seed to the nursery bed. Stepping onto the muddy-red terrace wall, with deft movements of his right hand, he scatters handfuls of seed. As seed strikes the water, shattering its mirror-perfect surface, another cycle of growth has begun. For the next nine months, until harvest, the attentions of cultivators and ritual practitioners will be focused on the water-filled terraces.

Across the terraces another plant, the water fern azolla, also grows, covering the fields with a green, moss-like cap. Although nitrogen constitutes about 80 percent of the earth's atmosphere, most plants cannot use it in its gaseous form. In wet-rice terraces, azolla, in symbiosis with the blue–green alga *Anabaena azollae*, produces a steady supply of nitrogen in a usable form, ammonium. When the rice fields are drained after harvest, nitrogen from decomposing azolla is absorbed by terrace soils.

The critical role of azolla has not gone unnoticed by the wet-rice farmers of Asia. In Vietnam, for example, a temple was erected in honor of azolla. Ritual verses suggest that the Toraja too knew of the importance of water fern in the wet-rice landscape:

> Hail to thee wet-rice field, with duckweed as a sunshade,
> Abundant be the blessings upon the *sawah*, full of spear-shaped water plants.

It is possible that the "sunshade of duckweed," more accurately translated as "moss," represents the mantle of azolla growing upon the surface of each terrace. For the Toraja, as for many Asian peoples, the sunshade is a sign of respect, status, and power. High-ranking Toraja were, in former days, shielded and honored by ceremonial umbrellas made of palm leaves. Toraja "big-men," or leaders, are likened in ritual verse to tall trees and immense umbrellas that protect a multitude of followers. The sun-shaded Toraja rice terrace of ritual verse is a noble presence in Toraja memory and landscape: it encapsulates ecological, cultural, and aesthetic wisdom within a single seed of multiple meanings.

Ceremonies of the Harvest

Harvest ceremonies mark the paths of rice in its journey from individual fields to family hearths, focusing attention on its transformations and on the social orchestration of cultivation. In late June, the sounds of handmade windmills can be heard in the fields. Startled flocks of crows and other *padi* birds take flight at the sounds of school children walking home on rice-*padi* paths. When mature rice plants bend with the weight of full kernels, it is time for preharvest rituals.

To Minaa Lumbaa, the ritual practitioner, stands in the corner of his field and chants:

> God who laid out the rice fields
> lord who spread out the broad plain
>
> God who delineated the offering places
> one after the other in the rice fields
> lord who marked out the places on the ground
> where the fragrant grass is burnt

Lumbaa cuts a handful a new rice and returns to his village, where women conduct rituals at the places and for the processes of transformation which they alone control: for the mortar log (where rice is separated from the stalk); for the winnowing trays (where the grain is separated from the chaff); and at the hearth, center of the Toraja household and the site of a most fundamental transformation: becoming food.

In a silent ceremony, Lumbaa's wife, like other women on the mountain that evening, grasps two ears of newly cut rice in her hand and touches the three hearthstones, the clay cooking pots, the coconut-shell water dipper, the large and small rice spoons, and plates. The two stalks of rice are given a name, "The Ears of the Hearth," and are hung like Christmas stockings above the cooking place.

Like the cursor of a computer screen, or the dotted line of an animated map that links points in a landscape itinerary, the actions of Lumbaa's wife illustrate certain ways in which ceremonies communicate information: through gesture, mime, and pointing. Her wordless, eloquent gestures emphasize and consecrate important places of the hearth.

Harvesters at work in the early morning, Mount Sesean.
Photograph by the author.

Men carrying bundles of *padi* on bamboo poles and in baskets, Mount Sesean. Photograph by the author.

The path of rice on the ritual map then moves to the "Meeting Place," the field where the major preharvest ceremony is conducted. This ritual clarifies, through the movements and exchanges of rice, the vital relations of reciprocity between cultivators, among villages in the region, and between the entire landscape-community, "Those of One Ritual-Celebration," and the spirits of the land.

At the preharvest ritual, women lade steaming heaps of new rice from their family fields into a single basket. The pooled rice of the community is spooned out on banana leaves, folded into conical packets, and fastened onto an altar. Palm wine, spirits for the spirits, as well as slices of pork, are also offered for spirits, ghosts, and ancestors. The altar stand and its gifts are a temporary architectural embodiment of an invisible hierarchy.

The Rice Dispersed, The Gift Returned

Lumbaa calls forth the spirits from their dwelling places, from the skies, from the springs, from the wells, and from the twelve layers of the earth "beneath our feet," inviting them to partake of the new rice. Ritual verse suggests that spirits not only dwell within the landscape, but embody it:

> God below us, upon whom the houses are built
> lord upon whom the poles, cut to the correct size, are erected
>
> God who placed himself as the floor of the earth
> lord who is the under layer of it.

The land which has been planted, weeded, seeded, and harvested, is the body of the spirits. The gift of abundance is thus returned by the community, through offerings of the firstfruits of cultivation. After the spirits are symbolically served, ritual practitioners are given a real meal consisting of rice of many kinds: red, purple, and highly prized glutinous rice are piled into the practitioners' goblet-shaped plates, in quantities befitting their roles as masters of ceremony.

The community of participating households, the "many people" of one ritual celebration, are then given their share-out of rice. Like the inhalation of a single breath, the produce of single fields, separately cultivated, yet collectively harvested, is pooled in a basket brimming with the rice of many farmers. This first phase of the preharvest ritual is centripetal, forming a nucleus of persons and rice grains on the ritual field and in the ceremonial basket. Then, like breath released, rice yielded up is returned: a gracious movement of dispersal. Rice, symbol and substance of Toraja prosperity, flows outward from a ceremonial center to its original donors, the spirits, its guardians, the ritual practitioners, and its cultivators, the rice farmers.

Before written texts compressed, codified, and preserved information about the techniques of agricultural production, before computer display screens and floppy disks presented a multitude of images and information, the landscape rituals of many preliterate peoples, including the Toraja, played a crucial role in the preservation of environmental information. These ring cycles of the seasons, timed to the sun and keyed to the constellations, encapsulated in dramatic forms, images and information about the environment. Agrarian ceremonies were indispensable for the perpetuation of the environment and the continuity of societies dependent, in large measure, on protein obtained from the wet-rice landscape.

Toraja rice-related rituals frame the structure of the wet-rice landscape by marking and linking crucial nodes in the natural and social environment. They compose the frames of landscape memory and perception, signalling the importance of water sources, instruments of cultivation, components of the irrigation system, and the social collectivities that make cultivation possible. Like the seeds whose cycles they inaugurate, celebrate, and close, these ceremonies convey a surplus of information concerning topography and timing, the instruments and substances of cultivation.

To minaa, "The Wise Ones," and *indo' padang,* the "Guardians of 100,000 Prohibitions," are the bearers of landscape ceremonies. These masters

Harvested *padi* drying in the sun on a lichen-covered boulder, Mount Sesean. Photograph by T. Volkman.

of memory and ceremony held to insure the preservation of the wet-rice landscape by remembering ritual verses and the structure of agrarian ceremonies. They are indeed the Mothers of the Land, engendering through remembering.

Memory and Commemoration

Customs of the ancestors we perform
They refuse to be left behind
Returning to be remembered
—Ritual Song, Mount Sesean

Toraja ceremonies of the landscape do not represent neutral information or environmental "data." Nor are these rituals moving solely in that they are kinetic, occasionally frenetic. Toraja ritual moves men through commemorating (recommitting to common memory) shared images and feeling about the wet-rice landscape, its community of spirits, plants, and persons, as well as irrigation channels and terraces. These cyclical ceremonies revivify Toraja understandings of the moral tissue of interconnections throughout the highlands environment.

Toraja rituals of the wet-rice landscape stir the senses and appeal through many channels: sight, hearing, smell, and a sharply focused sense of ordered beauty. And, through a multiplicity of expressive forms: the spoken arts of oratory, the animate arts of ritual architecture, the silent arts of mime, gesture, and simple pointing, the lively commotion of dogs yapping, smoke rising, and ritual speakers ceaselessly chanting.

If the rising column of smoke from offerings of aromatic grass is a sign of the directionality of communication between men and the spirits of the land, the movements of Toraja rice and its rituals through the landscape are the tracks of a particle of belief in the cloud chamber of an agrarian landscape.

Toraja society is changing rapidly. Indonesian education and ideology, consumerism, and Western tourism, among other influences, are affecting Toraja conceptions of the role, audience, and efficacy of religious ceremonies and their relationship to agrarian practices. Agrarian ceremonies and the beliefs that inform them will probably not exist two decades from now, at least in the forms we know them. For now, Toraja landscape rituals, and those of numerous other small-scale societies throughout the world, encapsulate and communicate in symbolic form what post-industrial societies have been forced, belatedly, to acknowledge and specify in quantitative form—namely, that what is taken from the environment must be returned. Perhaps this moral, sensuously conceived model of sustaining ecological relationships, of lasting reciprocity between people and land, is the gift of simpler, changing societies to those more powerful, a metaphor and model of fruitful environmental relations. In ritual verse, the Toraja exhort the desired contents of the entire world to flow toward their isolated mountain villages through the golden water-channels of their wet-rice landscape:

> We make a water-channel for you to come
> We build a stone bridge for you
> We make a golden waterworks
>
> The bounty will arrive here
> Like the sea encircling the earth
> And there will be no brokenness.
>
> —*To Minaa* Lumbaa of Buntu
> Tagari village

Charles Zerner teaches botanical drawing at the Massachusetts College of Art. The recipient of a research fellowship from the Social Science Research Council, he currently is studying the impact of tourism on the landscape of South Sulawesi.

Thoreau studied the science of botany to communicate with botanists—and to better express himself

Thoreau as Botanist: An Appreciation and a Critique

Ray Angelo

Thoreau was not the first to botanize in his hometown of Concord, Massachusetts. Two brothers, Drs. Edward and Charles Jarvis, of the generation before him collected many specimens in the town before Henry had graduated from Harvard in 1837. Thoreau certainly was not the last to botanize there. His writings have fueled an interest in the flora of Concord that extends uninterrupted over a century and a half to the present day. Probably no other town in New England has had such long-standing and continuous attention devoted to its plants. Adorned with rivers, lush meadows, ponds, bogs, and calcareous cliffs, the venerable settlement has rewarded botanists with a floral variety unmatched, perhaps, by any other area in New England of comparable size (1,190 species and counting).

The beginnings of Thoreau's exposure to the science of botany date back to his schooldays at the Concord Academy (1828–33), where botany was one of the disciplines taught by Phineas Allen. Also at this time he attended lectures at the Concord Lyceum which included botany among other topics. When Thoreau attended Harvard (1833–37), botany was not offered as a course in itself but was included under natural history taught by the noted entomologist Thaddeus W. Harris. About this time a boarder with the Thoreau family, Prudence Ward, shared with him her interest in botanical studies. Thoreau later recollected in his *Journal* (December 4, 1856) that during this period be began to use Jacob Bigelow's *Florula Bostoniensis, A Collection of Plants of Boston and its Vicinity* (no doubt the second edition of 1824). Primarily, he was looking for popular names of plants and references to localities. Since he used no system, the Latin names he learned at this time were soon forgotten.

Upon graduation from Harvard Thoreau did some schoolteaching in his native town. Natural history was one of the subjects he taught. He told his pupils that he knew the blossoming times of the local flowers well enough that he could determine what month it was by what was in flower. In 1842 he was asked to review for *The Dial* a series of natural history reports commissioned by the Commonwealth of Massachusetts. Included in the series was the Rev. Chester Dewey's *Report on the Herbaceous Plants of Massachusetts.* The ostensible review, entitled "Natural History of Massachusetts," does not include a single Latin plant name, perhaps intentionally. Thoreau's concern was that mere lists of plants (which Dewey's work essentially was) were an inadequate expression of the state's floral resources. At this time Thoreau's botanical knowledge was insufficiently scientific for him to comment in detail on the technical merits of the report had he wanted to. Moreover, he had not travelled widely enough in Massachusetts to judge its completeness.

What survives of Thoreau's *Journal* and correspondence from the 1840s shows little stirring in the direction of scientific botany. In a letter to his sister, Sophia, on May 22, 1843, from Staten Island he writes, "Tell Miss Ward I shall try to put my microscope to a good use, and if I find any new and pressible flower, will throw it into my common place book." Thoreau's first use of a Latin name for a plant appears to be in his *Journal* (volume 2, page 9, of the new Princeton University Press edition of his *Journal*) where he refers

Portrait of Thoreau by Cynthia DeSando.

to "Mikania scandens," climbing hempweed, on September 12, 1842. This same passage in slightly modified form appears in Thoreau's *A Week on the Concord and Merrimack Rivers,* published in 1849 (page 44, Princeton edition).

The first use by Thoreau of a scientific name for a native plant in his published work appears to occur in 1848. The name "pinus nigra" is found in the original version of the "Ktaadn" essay that appeared in the *Union Magazine of Literature and Art* of that year. This was the name for black spruce (*Picea mariana*) used in Bigelow's manual. In a later version of the text Thoreau changed the name to that used in Asa Gray's manual, namely, "*Abies nigra*," and also inserted an additional Latin name, "*Vaccinium vitis-idaea.*" Thoreau's background in classical languages and his delight in etymology naturally attracted him to the Latin (and Greek) names of science.

Two events in the later 1840s played a major role in stimulating Thoreau's interest in systematic natural history. The first was the arrival in 1846 of a "true giant" in the realm of science at the time—naturalist Louis Agassiz, who accepted an appointment at Harvard. As A. Hunter Dupree has noted: "Not only his attainments but his remarkable personality created a sensation among the local scientists." The very next year Thoreau's correspondence with Agassiz's assistant, James Elliot Cabot, included frequent use of scientific nomenclature to discuss the collection of animal specimens.

The second event, which more directly crystallized Thoreau's botanical inclinations, was the publication in 1848 of the first edition of Asa Gray's *Manual of Botany.* The appearance of this work heralded the end of a long period during which New England botany had languished at a relatively rudimentary level. This manual for the identification of vascular plants, mosses, and liverworts of the northeastern United States was as dry as Dewey's report and Bigelow's manual, but it was far more comprehensive and accurate.

Two years earlier George B. Emerson's *A Report on the Trees and Shrubs Growing Naturally in the Forests of Massachusetts* had appeared. This work, while much more limited in scope, devoted more attention to the occurrence and usefulness of each species than any previous manual, and its descriptions were more detailed. Both Gray's manual and Emerson's report made use of a natural system to arrange their species rather than the artificial system of Linnaeus adopted by Bigelow. The availability of these two volumes, which were unlike any that had come before in New England, could not help but encourage a more systematic study of plants by Thoreau.

Thoreau's first work touching upon natural history after these events was *A Week on the Concord and Merrimack Rivers,* published in 1849. In this book Thoreau finally injects a measured dose of Latin nomenclature into his nature writing, particularly with respect to fishes. Agassiz is even mentioned. Thoreau's application of scientific names to plants, however, is sparing—limited to eight plants, all of them relatively common and easy to distinguish.

In the 1906 ("Walden") edition of Thoreau's

Journal, the first Latin name for a native plant occurs in an entry from May 1850—"*Prunus depressa*" (now *Prunus susquehanae*, sand cherry). From August 31 of this year onward, the use of scientific plant names becomes a regular feature of the spring, summer, and autumn pages of the *Journal*. Thoreau recalled later (December 4, 1856, *Journal*) that this was about the time he returned to the study of plants with more method. The year 1850 is also that to which the earliest specimens in his organized herbarium belong.

Over the next two or three years Thoreau undertook an intensive program to develop his mastery of Concord's flora. He read botanical works by François André Michaux, Edward Tuckerman, John Loudon, Asa Gray, and Carolus Linnaeus. In his *Journal* he noted comparisons of the artificial Linnaean ordering of plants with natural systems, but always with the comment that neither addressed the poetical aspects of plants. When he sought the literature rather than the science of plants he was told to his dismay by naturalist and Harvard librarian, Thaddeus W. Harris, that he had already read all there was.

His efforts in the field during these years produced complaints of too much observation:

> I have the habit of attention to such excess that my senses get no rest, but suffer from constant strain. . . . When I have found myself ever looking down and confining my gaze to the flowers, I have thought it might be well to get into the habit of observing the clouds as a corrective; but no! that study would be just as bad. (September 13, 1852, *Journal*)

> I feel that I am dissipated by so many observations. . . . I have almost a slight, dry headache as the result of all this observing. (March 23, 1853, *Journal*)

In the winter of 1852, when there were no flowers to observe, he undertook the study of lichens.

Not surprisingly, the conflict between Thoreau the Artist and Thoreau the Naturalist began to surface: "What sort of science is that which enriches the understanding, but robs the imagination?" (December 25, 1851, *Journal*); "I have become sadly scientific" (July 13, 1852, letter to Sophia Thoreau).

It is somewhat startling to realize what Thoreau did *not* know at the start of his program in 1850—particularly with respect to woody plants. Thoreau, three years after his stay at Walden Pond, had never distinguished the first native tree to blossom in spring, silver maple (*Acer saccharinum*) (May 1, 1852, *Journal*); was unaware that but one type of spruce, black spruce (*Picea mariana*), occurred in Concord (May 25, 1857, *Journal*); could not distinguish poison ivy (*Rhus radicans*) from poison sumac (*Rhus vernix*) (May 25, 1851, *Journal*); and did not know the common witherod (*Viburnum cassinoides*) (September 11, 1851, *Journal*). Thoreau later recalled this state of ignorance:

> I remember gazing with interest at the swamps about those days and wondering if I could ever attain to such familiarity with plants that I should know the species of every twig and leaf in them, that I should be acquainted with every plant (excepting grasses and cryptogamous ones), summer and winter, that I saw. Though I knew most of the flowers, and there were not in any particular swamp more than half a dozen shrubs that I did not know, yet these made it seem like a maze to me, of a thousand strange species, and I even thought of commencing at one end and looking it faithfully and laboriously through till I knew it all. I little thought that in a year or two I should have attained to that knowledge without all that labor. (December 4, 1856, *Journal*)

During the early 1850s Thoreau's passion for recording flowering dates and leafing of woody plants dawns. He described the great lengths he

The sketches accompanying this article are taken from the "Walden" edition of Thoreau's *Journal*.

went to at times to ascertain the exact date a particular flower opened—"running to different sides of the town and into neighboring towns, often between twenty and thirty miles in a day" (December 4, 1856, *Journal*). Understandably, he noted: "One has as much as he can do to observe how flowers successively unfold" (June 15, 1852, *Journal*). His fascination for flowering dates never abated. It was always a victory to discover a new station for a plant with an earlier blossom time:

"It will take you half a lifetime to find out where to look for the earliest flower" (April 2, 1856, *Journal*). In his last years Thoreau organized this and other phenological data spanning a decade into elaborate monthly charts. These may represent the skeleton of a contemplated volume portraying a representative year in Concord.

As Thoreau's botanical acumen rapidly developed, he accepted the role of town botanist. It was important to him to know the location of plants rare in Concord. He made one of his most noteworthy finds while surveying in November 1851—the climbing fern (*Lygodium palmatum*), a peculiarly attractive fern that is regionally scarce. In May 1853 he discovered the showy painted cup (*Castilleja coccinea*) and marvelled "how long some very conspicuous ones [flowers] may escape the most diligent walker, if you do not chance to visit their localities the right week or fortnight." In the same month he related in the *Journal* an amusing account of extracting the locality of the fragrant roseshell azalea (*Rhododendron roseum*) or pinxter-flower from a local hunter. He saw allegorical significance in the fact "that, when I thought I knew the flowers so well, the beautiful purple azalea or pinxter-flower should be shown me by the hunter who found it" (May 31, 1853, *Journal*). Part of his argument used to persuade the hunter, Melvin, was that "I was a botanist and ought to know."

Thoreau's botanical interest in Concord naturally overflowed into his travels away from his native town. The accounts of his earliest significant trips—*Ktaadn and the Maine Woods* (1848), *A Week* (1849), and *An Excursion to Canada* (1853)—contain for the most part references only to common plants with relatively little use of Latin names. The same is essentially true for *Walden* (1854). A trip to Mt. Wachusett, Massachusetts, in October 1854 is represented in his *Journal* primarily by a list of common names of trees and shrubs seen there. This is a forerunner of more extensive lists, primarily in Latin, prepared for later excursions. For example, plants collected on a journey to Vermont and New Hampshire in September 1856 were carefully listed in the *Journal*. Similarly, notes in the *Journal* on his July 1855 trip to Cape Cod are littered with the Latin names for those flowers peculiar to the coast. By contrast, his articles on Cape Cod that appeared in *Putnam's Magazine* that year contain only two scientific plant names.

By 1857 Thoreau had clearly progressed beyond the fledgling stage and was perhaps one of the more competent amateur botanists in Massachusetts. In this year he made one of the most detailed lists of plants recorded for one of his journeys—the Allegash trip to Maine. This occurs in the *Journal* (not published in the 1906 "Walden" edition) and as an appendix to *Maine Woods* (1864). This list also notes species seen on his Chesuncook trip to Maine in September 1853.

In July 1858 Thoreau made possibly his most significant contribution to New England botany. That month he ascended Mt. Washington, New Hampshire—the highest peak in New England—and prepared the most detailed list of plants by zones that had ever been made for this site, one not to be surpassed until the twentieth century. The month before he had similarly listed plants found on Mt. Monadnock, New Hampshire; he supplemented this list with more botanical notes after a return visit in August 1860. The listing of plants by zones was probably inspired by Alexander von Humboldt's famous correlation of altitudinal plant zones with those of latitude.

Thoreau's journey to Minnesota in 1861 was made at a time when his botanical prowess was considerable but when his health was failing. His enthusiastic companion, Horace Mann, Jr., was a young naturalist whose promising career in botany at Harvard was cut short by tuberculosis within the decade. Thoreau's notebooks for the journey are liberally sprinkled with scientific plant names—old friends and new. Included also were the customary lists of plants seen. This was to be essentially Thoreau's last botanical foray.

Although Thoreau demonstrated much botanical curiosity on his excursions, it was always Concord's flora that was dearest to him: "Many a weed here stands for more of life to me than the big trees of California would if I should go there" (November 20, 1857, *Journal*). On February 4, 1858, Thoreau was astonished to find Labrador tea (*Ledum groenlandicum*) in Concord. He had, however, anticipated the discovery a year and a half earlier: "But why should not as wild plants grow here as in Berkshire, as in Labrador? . . . I shall never find in the wilds of Labrador any greater wildness than in some recess in Concord" (August 30, 1856, *Journal*).

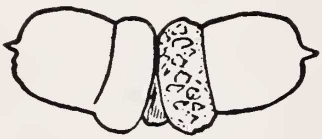
In the same swamp that harbored the Labrador tea, Thoreau noticed some curious growth on the black spruce there. Here he missed the opportunity to describe a plant at that time unknown to science: the locally rare parasite, dwarf mistletoe (*Arceuthobium pusillum*).

Starting about 1858 Thoreau undertook the study of grasses and sedges in earnest. These groups are relatively unfamiliar even to most modern botanists. Within two or three years he attained a substantial knowledge of those species that occur in Concord. His collections include nearly 100 species from the town (nearly half of those recorded in the town to date.) Other difficult plants groups such as lichens, mosses, and fungi resisted study owing to the absence of good regional manuals. Consequently, excepting lichens, his scientific references to these plant groups are minimal. Even with lichens he never came close to acquiring expertise comparable to what he achieved with vascular plants. In a short article entitled "Thoreau, the Lichenist" lichenologist Reginald Heber Howe, Jr., commented that Thoreau's observations of lichens showed "only a slight knowledge of species, and no technical grasp whatsoever." But Howe, who studied lichens in Concord about sixty years after Thoreau, noted that Thoreau knew the varied morphological types and appreciated their place in Nature. (See *The Guide to Nature*, volume 5, pages 17–20, 1912.) Any collections he might have made of lichens, mosses, and fungi are not known to have survived.

In his day there were relatively few regional botanists for Thoreau to share his observations with. The most notable New England botanist, Asa Gray (1810–88), at Harvard, was apparently not very accessible and was known to be primarily a herbarium botanist rather than a field botanist. A. Hunter Dupree, Gray's biographer, states that neither Ralph Waldo Emerson nor Thoreau crossed Asa Gray's path and attributes this to the empiricist Gray's hostility towards Transcendentalism.

Aside from Asa Gray, virtually all other botanists in New England at this time were amateurs. The most knowledgeable of these that Thoreau met was the Rev. John Lewis Russell (1808–73) of Salem, Massachusetts. Russell, a Unitarian minister, was for forty years professor of botany and vegetable physiology at the Massachusetts Horticultural Society and became a fellow of the American Academy of Arts and Sciences. He was well acquainted with men who described new plant species and for whom species were named. Russell was particularly interested in mosses, liverworts, and lichens. Since Russell was a classmate of Ralph Waldo Emerson's brother, Charles, at Harvard, it is likely that Thoreau first learned of Russell through Emerson. Russell visited Emerson in September 1838, at which time Emerson noted in his *Journal* that he was "A man in whose mind things stand in the order of cause & effect & not in the order of a shop or even of a cabinet."

What may have been Thoreau's first meeting with Russell occurred in Concord in August 1854. Thoreau's appetite for authoritative botanical identifications is evidenced by his notes for the three days he showed Russell around the town, which included a visit to the climbing fern. Russell made a second visit on July 23, 1856, to see a small yellow pond lily (*Nuphar* sp.). Russell must have noted Thoreau's increasing botanical proficiency and certainly was made aware of his new interest in grasses and sedges at the time of their last meeting on September 21, 1858.



That day Thoreau visited Russell at Cape Ann and the Essex Institute in Salem, Massachusetts. The day was divided between a morning with the Institute's collections and an afternoon in the field. Thoreau made the most of the opportunity to confirm identifications in difficult groups like willows (*Salix*) and lichens.

Other published botanists, such as Jacob Bigelow (1787–1879), professor of materia medica at Harvard, and George B. Emerson (1797–1881), both in the Boston area, apparently moved in social circles too rarefied ever to permit personal aquaintance with Thoreau. Schoolmaster and botanist Emerson was president of the Boston Society of Natural History, of which Thoreau was elected a corresponding member in 1850 (for contributing an American goshawk). According to A. Hunter Dupree, Emerson was dean of the scientific community in Boston and responsible for Asa Gray's appointment at Harvard in 1842. Though Thoreau made frequent visits to the collections and library of the Society, his interest there was primarily in fauna. Not being a regular member, he did not rub shoulders with members Gray, Bigelow, and Emerson. Consequently, Thoreau's meetings with Russell represent his closet contact with a botanist of professional caliber.

Although Benjamin Marston Watson (1820–96) was, strictly speaking, a horticulturist, his friendship with Thoreau provided an important opportunity to share botanical notes. Watson established his Old Colony Nurseries in Plymouth, Massachusetts, in 1845. This estate became a favorite retreat for the Transcendentalists of Concord. Thoreau in the same year (and only one month after setting up at Walden Pond) forwarded to Watson some fruit and seeds from some of Concord's uncommon trees and shrubs. The evident purpose was to assist Watson in his horticultural enterprise. Watson in turn sent Thoreau unusual specimens from his nursery, hired him to survey his farm, and invited him to lecture in Plymouth. Thoreau's *Journal* records regular visits to Watson in Plymouth where he could see living examples of plants foreign to New England.

A mutual friend of Thoreau and Marston Watson was George P. Bradford (1807–90), a teacher, who for a time did some market gardening with Watson in Plymouth and had been part of the Brook Farm experiment. He had taught a class in botany at a school for girls in Plymouth in 1830. The references to Bradford in Thoreau's *Journal* are brief, touching primarily on unusual botanical finds. There is the suggestion that Bradford shared a Transcendentalist interest in botany when Thoreau notes Edward Hoar's proposal that a leaf of the climbing fern be sent to Bradford "to remind him that the sun still shone in America" (August 14, 1854, *Journal*). Oddly, there is but one inconsequential reference to Bradford in Thoreau's published correspondence.

Bradford, Russell, and Austin Bacon of Natick are acknowledged in the preface to George B. Emerson's report on the trees and shrubs of Massachusetts. This preface approximates a directory of Massachusetts botanists in 1846. Austin Bacon (1813–88) was a surveyor–naturalist. Thoreau paid a visit to him on August 24, 1857, and was shown a number of Natick's botanical highlights. Thoreau's interest in Natick no doubt arose from his reading of Oliver N. Bacon's *History of Natick,* which included a list of unusual plants (January 19, 1856, *Journal*).

Among Concordians there were only Edward S. Hoar, Minot Pratt, and sister Sophia with whom Thoreau spoke about botany in any depth. Edward S. Hoar (1823–93), a retired lawyer, accompanied Thoreau on his trips to the White Mountains of New Hampshire and Maine's Allegash and Penobscot Rivers. He was also Thoreau's accomplice in the accidental burning of the Fairhaven Woods in Concord in 1844. Like Thoreau, Hoar collected plant specimens and pressed them. Indeed, Hoar's collections are much superior in quality, particularly with respect to the legibility and detail of his collection data. The majority of his specimens were collected from 1857 to 1860 and included many grasses and sedges. These were the years during which Thoreau undertook a study of the same difficult groups, but curiously the *Journal* offers no support for the idea that they studied together. The references to Hoar in the *Journal* do show that Hoar brought to Thoreau's attention various botanical curiosities that he found. It is evident that for Thoreau's northern journeys Hoar was the companion of choice because of his enthusiasm for natural history, particularly of the botanical variety.

Minot Pratt (1805–78), a farmer–horticulturist, moved to Concord after four years at the Brook Farm experiment. If there was anyone as intimately familiar with Concord's wild flowers as Thoreau, it was Minot Pratt. Apparently he was just as independent, since Thoreau's references to him in the *Journal* suggest only limited communication between the two about the location of Concord's rarities. On three occasions Pratt gave Thoreau a botanical tour of his neck of the woods—Punkatasset Hill and Estabrook Woods, some of the richest areas in the town botanically (August 17, 1856; May 18, 1857; and June 7, 1857, *Journal*). Pratt later engaged in a practice that has earned him a degree of notoriety among latter-day botanists, namely, the establishment of alien plants in Concord. Thoreau rarely did the same, but his introduction of *Nasturtium officinale* is an example (April 26, 1859, *Journal*).

Judging from her herbarium, which is now at the Concord Free Public Library, Sophia Thoreau (1819–76) had an interest in botany that was considerably less scientific than her brother's and more in the aesthetic vein. Many of her pressed plants consist of several species to a sheet, with an eye to attractive arrangement. There is rarely any information recorded as to their identity or location. Thoreau mentions three flowers in his sister's herbarium that he had not seen in Concord—whorled pogonia (*Isotria verticillata*), painted trillium (*Trillium undulatum*), and perfoliate bellwort (*Uvularia perfoliata*) (September 22, 1852, *Journal*). All are locally rare. Strangely, there is no evidence that Thoreau ever saw any of these within the bounds of Concord (where Sophia found them). This suggets a bit of sibling rivalry.

The general scarcity of botanists in New England in Thoreau's time undoubtedly arose from a virtual absence of illustrated manuals and popular field guides treating the flora of the region. These were to appear only later in the nineteenth century. Thoreau complained of this lack (compared to what the British had) indirectly: "A few pages of cuts representing the different parts of plants, with the botanical names attached, is worth volumes of explanation" (February 17, 1852, *Journal*). He found the plant descriptions available unsatisfactory, and they *were*: "I quarrel with most botanists' description of different species, say of willows. . . . No stress is laid upon the peculiarity of the species in question, and it requires a very careful examination and comparison to detect any difference in the description" (May 25, 1853, *Journal*); "You cannot surely identify a plant from a scientific description until after long practice" (April 26, 1857, Letter to B. B. Wiley).

Thoreau's library (as listed by Walter Harding in 1957) reflects the relative dearth of botanical references of the time. He owned almost all the volumes that would pertain to Concord's vascular flora and a number that were only marginally relevant. Harding's catalog includes the following botanical works:

The Vegetable Kingdom: or, Handbook of Plants and Fruits (Chapin)
Report on the Herbaceous Plants of Massachusetts (Dewey) and *Report on the Quadrupeds of Massachusetts* (Emmons) [both issued by the Massachusetts Zoological and Botanical Survey]
A Report on the Trees and Shrubs Growing Naturally in the Forests of Massachusetts (Emerson)
Culture of the Grasses (Flint)
Manual of Botany, 1st and 2nd editions (Gray)
A Popular History of British Lichens (Lindsay)
Arboretum et Fruticetum Britannicum (Loudon)
Encyclopaedia of Plants (Loudon)
Enchiridion botanicum; or, A Compleate Herball (Lovell)
Ferns of Great Britain (Sowerby)
A Popular History of British Mosses (Stark)

To this list should be added Jacob Bigelow's *Florula Bostoniensis* (various editions), which Thoreau must have owned, judging from the frequent *Journal* references to it. Three well-known manuals that Thoreau consulted from time to time were Amos Eaton's *A Manual of Botany for the Northern and Middle States* (various editions), John Torrey's *Flora of the Northern and Middle Sections of the United States* (1826), and Torrey and Gray's *A Flora of North America* (1838–43). None of these offered much more than could be found in the manuals of Bigelow and Gray. Torrey and Gray's work was the most thorough of the three but was unfinished and covered too much geographical territory to be convenient. If modern field guides and botanical manuals had been available to Thoreau, his expertise would have developed much earlier and much more rapidly. It is surprising that he managed as well as he did.

A well-identified herbarium is the ultimate all-season botanical reference work. Unfortunately, regional herbaria were also in their infancy in Thoreau's time. It is understandable that Thoreau did not miss the opportunity to examine the meager plant collections at the Boston Society of Natural History rooms (June 19, 1856, *Journal*) and the Essex Institute (September 21, 1858, *Journal*). The best collections, however, were in the custody of individuals and were private.

Thoreau's own herbarium (numbering in the end more than 900 specimens) was no doubt one of the larger collections in eastern Massachusetts at the time. Thoreau himself realized this, commenting in a letter to Mary Brown (April 23, 1858): "I should be glad to show you my Herbarium, which is very large." From a modern viewpoint the data he recorded for his collections are, on the whole, poor. Approximately one-half of the specimens note only the identity of the plant, omitting the most important bit of information—the locality. This detracts significantly from the scientific value of the collection. In the difficult groups like grasses, sedges, and willows his data are generally much better than the remainder of the collection but frequently difficult to decipher (written small, in pencil, and hurriedly or carelessly). His habit of using his straw hat as a botany box to bring home plants collected in the field tended to encourage the gathering of small, inadequate, or incomplete samples.

Thoreau evidently started his organized herbarium (as opposed to casual collections placed in commonplace books or manuals) about 1850, judging from the earliest dated specimens. This

was the same period when he began to study botany with more method. Clearly Thoreau created his herbarium as an aid in sorting out the identities of plants he found in Concord and on his travels and not as a vehicle for preserving his memory among future botanists (a common purpose of private herbaria).

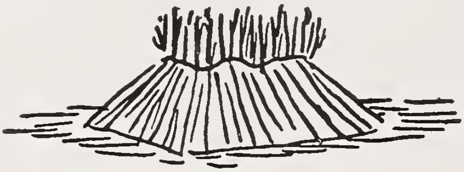
The disposition of his herbarium following his death was that, at his request, about 100 grasses and sedges were given to his botanical companion, Edward Hoar, and the remainder (some 800 specimens) were given to the Boston Society of Natural History. Thoreau's grasses and sedges in the possession of Hoar, along with most of Hoar's own collection, were eventually given to the New England Botanical Club by Hoar's daughter, Mrs. M. L. B. Bradford, in 1912. The Club's herbarium is currently housed at Harvard University. The Thoreau specimens have been carefully mounted on standard-sized herbarium sheets together with Thoreau's pencil-scribbled scraps of data and Hoar's transcription of them. This is the most scientifically useful part of Thoreau's herbarium owing to the presence of collection data, the difficulty of the plant families involved, and the addition of annotations by later botanical experts such as M. L. Fernald.

The bulk of Thoreau's herbarium stayed with the Boston Society of Natural History until 1880, when it was given to the Concord Free Public Library. In 1959 the Library turned the collection over to Harvard University's Gray Herbarium, where it resides currently separate from their main collection. Unlike Thoreau's grasses and sedges, this part of the collection appears for the most part to be in the condition in which he left it at his death. Because of its relative inaccessibility and lesser scientific value, it has received relatively little critical attention by later botanists. The specimens are somewhat insecurely attached with pieces of tape to elephant folio-sized sheets of flimsy paper. Occasionally smaller sheets of paper are used. There is usually more than one specimen to a sheet, sometimes six or more, and frequently more than one species to a page. Typically, only the Latin name for the species is written in pencil near the specimen. Locality data such as "Truro '55." "Brattleboro," and "Maine '57" are sometimes noted in pencil beside particular specimens or scribbled on small scraps of paper slipped under the specimens. The sheets are numbered in pencil and arranged in systematic order according to Gray's *Manual of Botany* (second edition). The collection is divided into six parts, each kept in a large, worn cardboard portfolio. A listing of species was made by the Boston Society of Natural History in a separate notebook.

In contrast to his sister's herbarium, Thoreau's collection is well organized and the placement of specimens on the sheets is determined by practicality rather than aesthetics. In spite of some careless handling and neglect, the specimens at present are generally in good condition. There is surprisingly little evidence of insect damage. A few specimens retain enough of their original bright tints that they appear to have been pressed within the past year. The fragility of the collection will continue to leave it vulnerable to inadvertent mistreatment by those unfamiliar with the proper manner of handling pressed specimens.

Within his lifetime Thoreau published but one work concerned with the world of plants. This is his essay "The Succession of Forest Trees," delivered as an address before the Middlesex Agricultural Society in Concord in September 1860 and published the following month in the *New York Tribune* and in regional agricultural reports. It is properly regarded as a contribution to ecology rather than to botany, but is, perhaps, his most important scientific work (representing not so much original ideas as an original development and formulation of ideas).

Thoreau's essays "Autumnal Tints" and "Wild Apples," derived from his *Journal* and presented as lectures, were revised during the last months of his life and published posthumously in the *Atlantic Monthly* in 1862. These essays are part of Thoreau's attempt to fill a void that he felt existed in the literature of botany. When he first began his study of plants in earnest he had sought



out "those works which contained the more particular *popular* account, or *biography*, of particular flowers, . . . for I trusted that each flower had had many lovers and faithful describers in past times" (February 6, 1852, *Journal*). "Autumnal Tints" and "Wild Apples" present an aesthetic appreciation of plants. While grounded in science, the essays are in fact examples of literature.

Among the fragmentary manuscripts left by Thoreau are what appear to be a series of essays he was working on with titles "Wild Fruit," "The Dispersion of Seeds," "The Fall of the Leaf," and "New England Native Fruits." From these manuscripts Leo Stoller has pieced together an essay entitled "Huckleberries," the style and content of which very much parallels "Autumnal Tints" and "Wild Apples." A key phrase in the essay is "The berries *which I celebrate*" (italics Thoreau's), indicating the spirit intended in these pieces.

Thoreau's studies in botany did not result in significant contributions to the science of botany. Most New England botanists would be hard pressed to identify his most important botanical achievement—the first detailed description of the vegetation zones on New England's highest peak, Mt. Washington. Although the description was not published until well after his death, his observations provide a point of comparison that reveals changes in alpine vegetation at New England's most interesting botanical site.

Thoreau's extensive study of the plants of Concord also serves as a point of comparison for noting changes in the flora. It is important for this reason, rather than for resulting in particular botanical finds in Concord. His observations and collections in Concord represent, perhaps, the most complete survey of a New England town's flora up to that time. Thoreau in essence has provided later botanists with a "photograph" of Concord's flora in the 1850s. None of Concord's other botanists have matched the intensity of activity that engaged him during that decade. His plant identifications (once he passed beyond the novice stage) were very competent, with doubts or errors occurring only at those points where the professional botanists themselves (and their manuals) were confused. Thoreau's intimate familiarity with the location of unusual plants in Concord was equalled only by Minot Pratt. The breadth of Thoreau's botanical knowledge (which included grasses, sedges, and lichens) has been approached only by Edward Hoar, and by the late Richard J. Eaton of the twentieth century.

It was not Thoreau's aim to add to the body of botanical knowledge of his time. Rather, his efforts arose from a desire to distinguish more clearly the textures with which Nature clothed his native town, and his New England, since he felt himself to be part of the same fabric: "I am interested in each contemporary plant in my vicinity, and have attained to a certain acquaintance with the larger ones. They are cohabitants with me of this part of the planet, and they bear familiar names" (June 5, 1857, *Journal*). Domesticated plants were of little or no interest to him: "I was never in the least interested in plants in the house" (December 4, 1856, *Journal*). His early attention to flowers was coincident with the general Transcendentalist view of Nature—as a source of inspiration, a living lesson from which to extract a moral, an invitation to experience rather than an opportunity to analyze. Later, his systematic approach to plants was undertaken with philosophical discomfort and ensuing rationalization: "Once I was part and parcel of Nature; now I am observant of her" (April 2, 1852, *Journal*); "One studies the books of science merely to learn the language of naturalists—to be able to communicate with them" (March 23, 1853, *Journal*). To the end he considered himself not a naturalist or botanist but a writer, first and foremost: "Here I have been these forty years learning the language of these fields that I may the better express myself" (November 20, 1857, *Journal*). Yet, for a writer to acquaint himself so completely and consciously with the flora of his native region was unprecedented, and inspires wonder as to what grand work of prose this insistent pursuit of botany was meant to nurture.

Ray Angelo is curator of the vascular plant herbarium of the New England Botanical Club.

Some very ingenious sleuthing leads to a long-lost stand of *Lygodium palmatum*

Thoreau's Climbing Fern Rediscovered

Ray Angelo

[*In preparing his botanical index to Thoreau's* Journal (*reviewed on pages 30 to 32*), *Ray Angelo did a great deal of painstaking research, not all of it in herbaria and archives. Sometimes, map in hand and armed with historical data gleaned from many quarters, Angelo hunted down the sites of noteworthy plants Thoreau mentioned in his* Journal. *Following is his account of a successful search for the stand of climbing fern* (Lygodium palmatum) *that Thoreau discovered in Concord, Massachusetts, in 1851. Angelo's account is reprinted with permission from* Thoreau Society Bulletin 149 (*Fall 1979*).]

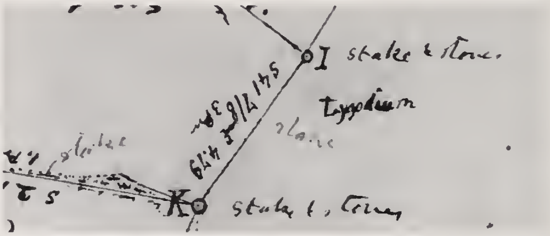
While surveying the Ministerial Swamp in Concord, Massachusetts, on November 24, 1851, Henry Thoreau came upon a rare and unusual fern—the climbing fern (*Lygodium palmatum*)—the only fern in New England that twines like a vine. Thoreau wrote of it in his Journal on July 30, 1853:

> It is a most beautiful slender and delicate fern, twining like [a] vine about the stem of the meadow-sweet, panicled andromeda, goldenrods, etc., to the height of three feet or more, and difficult to detach from them. . . . Our most beautiful fern, and most suitable for wreaths or garlands. It is rare.

and, on August 14, 1854:

> 3 P.M.—To climbing fern with E[dward]. Hoar. It takes a good deal of care and patience to unwind this fern without injuring it. Sometimes same frond is half leaf, half fruit. E[dward]. talked of sending one such leaf to G[eorge]. Bradford to remind him that the sun still shone in America.

In 1857 Thoreau sent a spray of the fern to Miss Mary Brown of Vermont and remarked that the



Part of the Thoreau survey map that led the author to the lost colony of climbing fern. The word "Lygodium" marks the colony. Used with the permission of the Concord Free Public Library.

name "climbing fern" would have been "a pretty name for some delicate Indian maiden." There are at least fourteen Journal entries from 1851 onwards referring to the climbing fern (also called "lygodium" or "tree fern" by Thoreau).

He disclosed the location to a number of friends. One of these would be Minot Pratt (1805–1878). Some time in the 1850s, Pratt showed the rarity to Miss Annie Sawyer, who later gave the following account:

> Mr. Pratt had promised to take me to the only place in Concord where the climbing fern could be found. I had given my word of honor that I would not tell, and in due season we were on the ground. In the midst of our enjoyment we heard a snapping of twigs, a brisk step, in the bordering thicket, and in a second Mr. Thoreau's spare figure and amazed face confronted us. Mr. Pratt answered for my trustworthiness, and so won over Mr. Thoreau by representing what a deed of charity it was to enlighten my ignorance. . . .

The climbing fern colony rediscovered in 1978 by the author. Photographed in 1901 by Herbert W. Gleason. Used with the permission of the Concord Free Public Library.

> Thoreau often visited the west part of Concord, . . . where he first found the climbing fern. The writer saw him the day he found the rare plant while returning home with his prize. I never saw such a pleased, happy look on his face as he had that day. He took off his hat, in the crown of which the fern was coiled up, and showed me the dainty, graceful glory of the swamp.
>
> —Horace R. Hosmer, *Concord Enterprise*, April 22, 1893

In an 1863 article for the newspaper *Commonwealth* Pratt wrote: "In a wild spot . . . (long may it remain secluded), the graceful climbing fern, very rare, and the large purple orchis . . . are found."

Pressed specimens of the fern collected from Concord by Thoreau's sister Sophia, and by others were all certainly taken from the same colony that Henry discovered.

Some time after 1920, knowledge of the exact location of the colony became lost. By the time Concord's foremost botanist, the late Richard J. Eaton, started inquiring about it, no one could tell him precisely where it was or had been. He searched the Ministerial Swamp repeatedly without success and concluded in his *A Flora of Concord* that the colony had probably been exterminated by the dumping of rubbish.

Mr. Eaton apparently concentrated his search in the vicinity of two small bogs in the swamp. However, Thoreau did not associate the fern with the bogs, while both Minot Pratt and Alfred W. Hosmer (1851–1903) mention the colony as occurring in "woods." The label on a specimen of the fern collected on August 6, 1899, by Alfred Hosmer describes the habitat as "dense, low, shady woods among thick bushes."

In the Concord Free Public Library there is a photographic plate of the fern taken by the well-known nature photographer Herbert W. Gleason. Unfortunately, it shows little of the background. Reference Librarian Marcia E. Moss, produced from the library archives a key piece of evidence—the survey sketch of the Ministerial Swamp that Thoreau prepared at the time he discovered the fern. At one spot on the map in tiny print is the word "Lygodium." It is not near the bogs in the swamp.

Mary Fenn of Concord (who has had a long-standing interest in the climbing fern) and I set out for the Ministerial Swamp on November 6, 1978, with a photocopy of Thoreau's 1851 survey map in hand, courtesy of the Library through Marcia Moss. We proceeded to a low thicket that seemed to correspond to the spot indicated on the map. A careful search of the thicket proved unsuccessful. Reexamining the map carefully and noting its scale, I did some pacing that indicated the thicket was not the place to look. We decided to search a swath of woodland that was in better agreement with the survey map. We had not taken more than a few strides when I noticed a peculiar growth five to ten yards ahead. . . .

In the most ordinary of woodland settings the climbing fern sprawled over an area about three yards wide and five yards long. Being an evergreen fern, it could not have been displayed to better advantage than amidst the sere hues of late autumn. For more than half a century the delicate maiden had quietly waited, avoiding the gaze of all, until the arrival of two well-wishers bearing a remembrance from six score and seven Novembers past.

Ray Angelo is curator of the vascular plant herbarium of the New England Botanical Club.

This unusual plant should not be transplanted from the wild but can easily be raised from spores

Raising the Climbing Fern from Spores

William E. Brumback

The climbing fern (*Lygodium palmatum*) occurs mainly along the Atlantic coastal plain in moist, acid soil, in thickets and open woods and along streambanks from Georgia to southern New Hampshire and north-central Vermont. Although the species may be abundant where it is found, populations are usually rare and localized. In each New England state in which the climbing fern occurs (all but Maine), it is on the state's rare and endangered list. In addition to being rare, the climbing fern is difficult to transplant; thus, it should not be collected from the wild except in cases where its destruction is imminent.

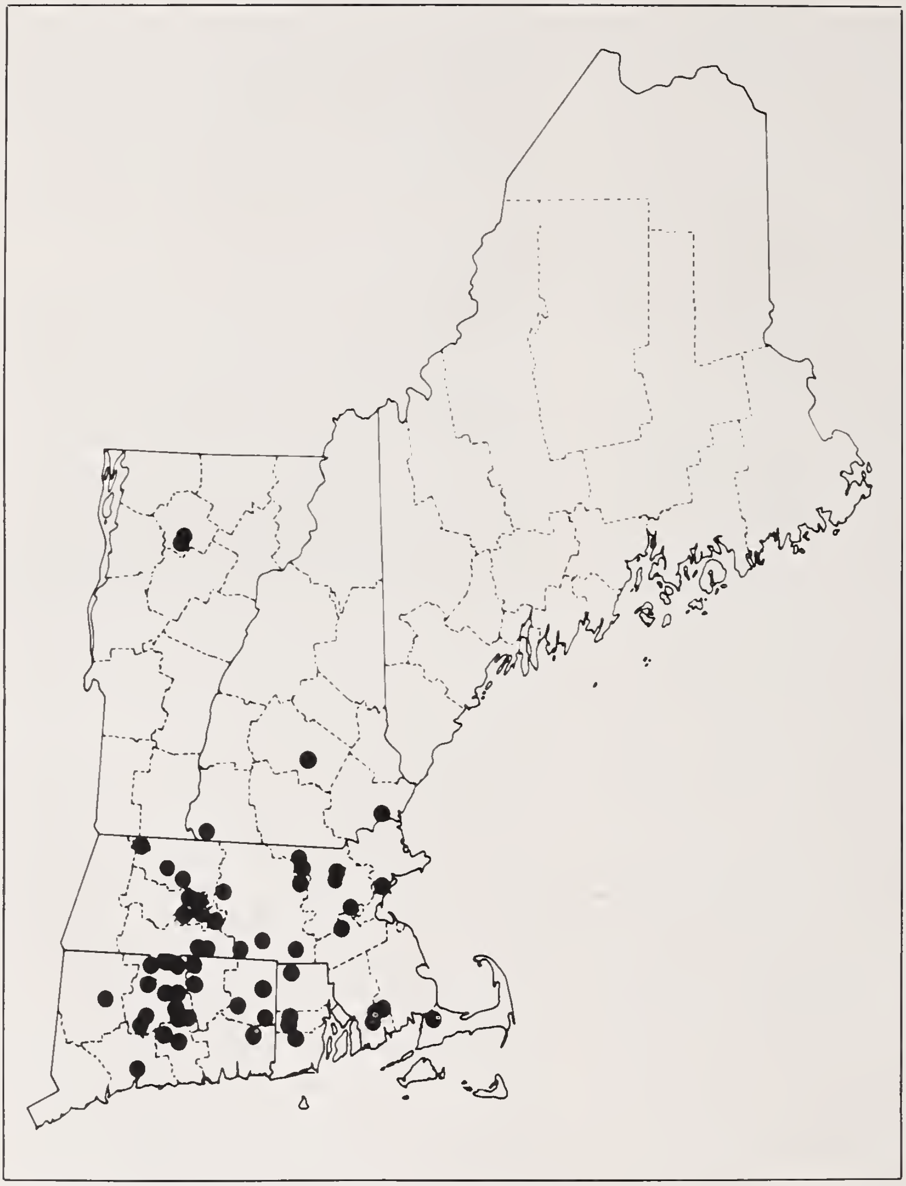
Luckily, the climbing fern grows easily from spores. Although the fertile leaves appear as early as August and September, I usually wait until late November to collect the fertile leaves from our plants at the Garden in the Woods. The Garden's plants, rescued from Enfield, Massachusetts, before the town was inundated by Quabbin Reservoir, are thriving and spreading by spores in the moist, acid soil of the bog gardens. I raise the climbing fern from spores as follows.

The spores are either sown under lights in the basement or in a cool, shaded greenhouse for slow germination later in the spring, or are stored dry in a plastic container in the refrigerator for sowing later. Fresh spores probably germinate best, but refrigerated spores have also produced excellent results.

Sterility is an important factor when sowing the spores of any fern species. Using a clean container and a sterile commercial seed-growing medium helps to ensure sterility. Mix an equal part of sterilized peat moss with the medium to provide an acid soil, water the mixture thoroughly, and allow it to drain. Scrape the spores from a leaf onto a clean sheet of paper. It is difficult to avoid mixing pieces of the leaf in with the spores. Although leaf debris can provide a base for molds and other fungi, I have in many cases sown quite a bit of the dried leaf along with the spores. Some contamination has always occurred, but I have been able to eliminate it easily with a light application of fungicide (Benelate). In any event, fold the sheet of paper into a U and, while moving it in a circular motion, tap the spores very lightly and evenly over the surface of the soil. Soak the container in a water bath, with the water level about half the depth of the soil. When the soil is thoroughly moist, remove the container and allow it to drain. Put the container in a plastic bag and seal the bag with a rubber band. Place the enclosed container in a well-lit area at room temperature ("grow-lights" are very good for this purpose) or in a cool greenhouse, or on a window sill. Do not allow direct sunlight to strike the bag because it will cause overheating.

Ventilate the bag every day or two, bottom-watering the container whenever the surface of the medium looks dry. Allow twelve weeks for the spores to germinate, longer if the container is being kept in a cool place. The prothallia will first appear as a green tint on the soil surface, and the young ferns will have put up their first true leaves by July. At this time, carefully thin the ferns by putting them into separate containers at a density of about one plant per square inch. Moisten, again by bottom-watering, and put the containers into plastic bags. (If the ferns were not overcrowded in the first place, you may not have to thin them.)

About one month after you have thinned the



Colonies of the climbing fern (*Lygodium palmatum*) in New England (dots). The plant occurs in widely scattered stands throughout its range. Map reproduced from *New England's Rare, Threatened, and Endangered Plants*, by G. E. Crow (1982).

ferns, begin to acclimate them to lower humidity by ventilating the plastic bags a little longer each day. Finally, remove the containers completely from the bags. Keep the containers in a cold frame or other protected area over the winter and plant them out in spring, after the danger of frost has passed.

The climbing fern is difficult to establish even when it is planted in moist, acid soil in light shade. Although it will grow quite well in a prone

Fertile pinnae of the climbing fern, showing the sori. Courtesy of Alice F. Tryon. Photograph by Robert L. Coffin.

Scanning electronmicrograph of a spore of the climbing fern. The spore is about one-five hundredths of an inch in diameter. Courtesy of Alice F. Tryon.

position, for best effect it should be given a low wall or shrub on which to clamber.

If the climbing fern becomes established in your garden, you may want to share it with friends. A plant can be divided, but its rhizome, or rootstock, breaks easily. Furthermore, since most of the slender rhizome is hidden just below the surface of the soil, it often is difficult to determine just how large a piece you are digging. The size of a plant can be determined when the fiddleheads emerge in late spring. I usually divide plants in the fall, however, removing an eight-inch-diameter ball of soil around each established plant so that there will be enough rhizome to emerge the following spring.

The American Fern Society (care of Dr. James D. Caponetti, Department of Botany, University of Tennessee, Knoxville 37916-1100) conducts a spore exchange. A limited number of climbing fern plants are available for purchase at the New England Wild Flower Society's Garden in the Woods (Hemenway Road, Framingham, Massachusetts 01701). Members of the Society receive a yearly list of seeds and spores offered for sale.

William E. Brumback is propagator at Garden in the Woods, Framingham, Massachusetts.

BOOKS

Botanical Index to the Journal of Henry David Thoreau, by Ray Angelo. Salt Lake City: Gibbs M. Smith, Inc.—Peregrine Smith Books, 1984. 203 pages. $20.00.

ALBERT W. BUSSEWITZ

Even the most casual reader of Thoreau's fourteen-volume, two million-word *Journal* quickly realizes that Thoreau was deeply interested in plants, especially the plants of his native town of Concord, Massachusetts, and its environs. Through a lucky collaboration between two publishers and a New England botanist, we now have the *Botanical Index to the Journal of Henry David Thoreau* to guide us through the massive *Journal*. The *Thoreau Quarterly*, a small literary magazine published at the University of Minnesota, and Peregrine Smith Books of Salt Lake City are the publishers; Ray Angelo, until recently a resident of Concord, is the botanist. Affiliated for the past several years with the New England Botanical Club, Angelo already had two botanical field guides and a number of botanical articles to his credit, but the major impetus behind the *Botanical Index* was, no doubt, his longstanding personal espousal of Thoreau's philosophy of life.

Just riffling through the *Botanical Index*'s columns, which are tightly packed with common and scientific names, will dispel any lingering doubts one might have had about the breadth of Thoreau's botanical pursuits. No other aspect of the natural world is more intimately associated with Thoreau's walks and observations than plants—wildflowers, grasses, trees, and shrubs. The *Journal*'s references to pines, willows, and oaks alone run into the thousands; Thoreau's deep fondness for the "villageous elm" is reflected in over four hundred entries in the *Index*. In an era when regional herbaria were uncommon, Thoreau's personal herbarium consisted of over nine hundred specimens, many of them fetched home from the fields in the crown of his straw hat!

Angelo has prefaced his admirable *Index* with a meticulously researched essay on "Thoreau as Botanist" (reprinted in this issue of *Arnoldia*). He traces the origins of Thoreau's interest in plants, identifying the major events that shaped his growth in that developing field of science. Thoreau's credentials as a botanist are fully explored and evaluated. Angelo sketches the state of the art in Thoreau's time, discussing both the botanists of the day and the paucity of published information on plants. Singled out are the botanists and plant manuals that most influenced Thoreau's development over the course of two decades or more, particularly of his growing involvement in identification and concern for collection data. Angelo also traces Thoreau's progress as a plant collector and assesses his contribution to the botany of his day. Withal, the essay is a most valuable source of insight into Thoreau's standing as a botanist and into the botanical aspects of the *Journal* itself.

In organizing his *Index*, Angelo considered the needs and interests of both amateur and professional botanists, as well as of the general reader, according appropriate deference to both common and scientific names. He carefully selected a modern common name and linked it with the modern binomial. (The eighth edition of *Gray's Manual of Botany* is the standard for the scientific names. As Angelo points out, this work, published in 1950, does not reflect recent taxonomic refinements yet remains a standard reference for the New England flora, and is the reference most

A pressed specimen of Long's wool-grass (*Scirpus longii*) from Thoreau's herbarium, now part of the herbarium of the New England Botanical Club. Photograph by Peter Del Tredici.


HERBARIUM OF EDWARD S. HOAR

heavily drawn upon by modern plant guides.) Many of the common names Thoreau used are obsolete, but Angelo has indexed them and assigned them to their proper scientific niches. When confronted with misidentifications or similar problems of nomenclature, Angelo simply took to the field to clarify things, or referred directly to Thoreau's own collection or to the Harvard herbaria. All of the names are cross-referenced.

To the *Index* is appended a very considerable body of notes (three hundred forty-one in all!) that enlighten the reader on a broad range of matters botanical—especially on identities, distributions, and unresolvable uncertainties. All of the notes are linked to entries in the main body of the work. The great abundance of the notes we owe to Angelo's penchant for exactitude—the hallmark of a botanist.

Doubtless this *Botanical Index,* with its ancillary information and useful insights, will serve all levels of the botanically curious. All readers who would approach Thoreau from the viewpoint of his relationship to the plant world now have a guide of great clarity and detail. Yet an even greater virtue of the *Index* may be its ability to draw readers a bit closer to the heart and mind of a "monotypic" botanist and journal-keeper who "frequently tramped eight or ten miles through the deepest snow to keep appointment with a beech tree, or a yellow birch, or an old acquaintance among the pines."

The *Index* was published simultaneously in two formats, which differ only in their covers. One, the *Index* alone, was issued by the *Thoreau Quarterly* as its Volume 15, and is available from the *Quarterly* (Department of Philosophy, University of Minnesota, Minneapolis 55455) for $20. The other, the *Index* plus a paperback reprinting of Thoreau's *Journal* in fourteen volumes (the *Index* is the fifteenth volume), is available from Peregrine Smith Books (Post Office Box 667, Layton, Utah 84041) for $125.

Albert W. Bussewitz, a naturalist and photographer, participates actively in the Arboretum's Volunteer Program. For many years he was on the staff of the Massachusetts Audubon Society.

The Arnold Arboretum of Harvard University, a
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Fall 1985

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The Magazine of the Arnold Arboretum

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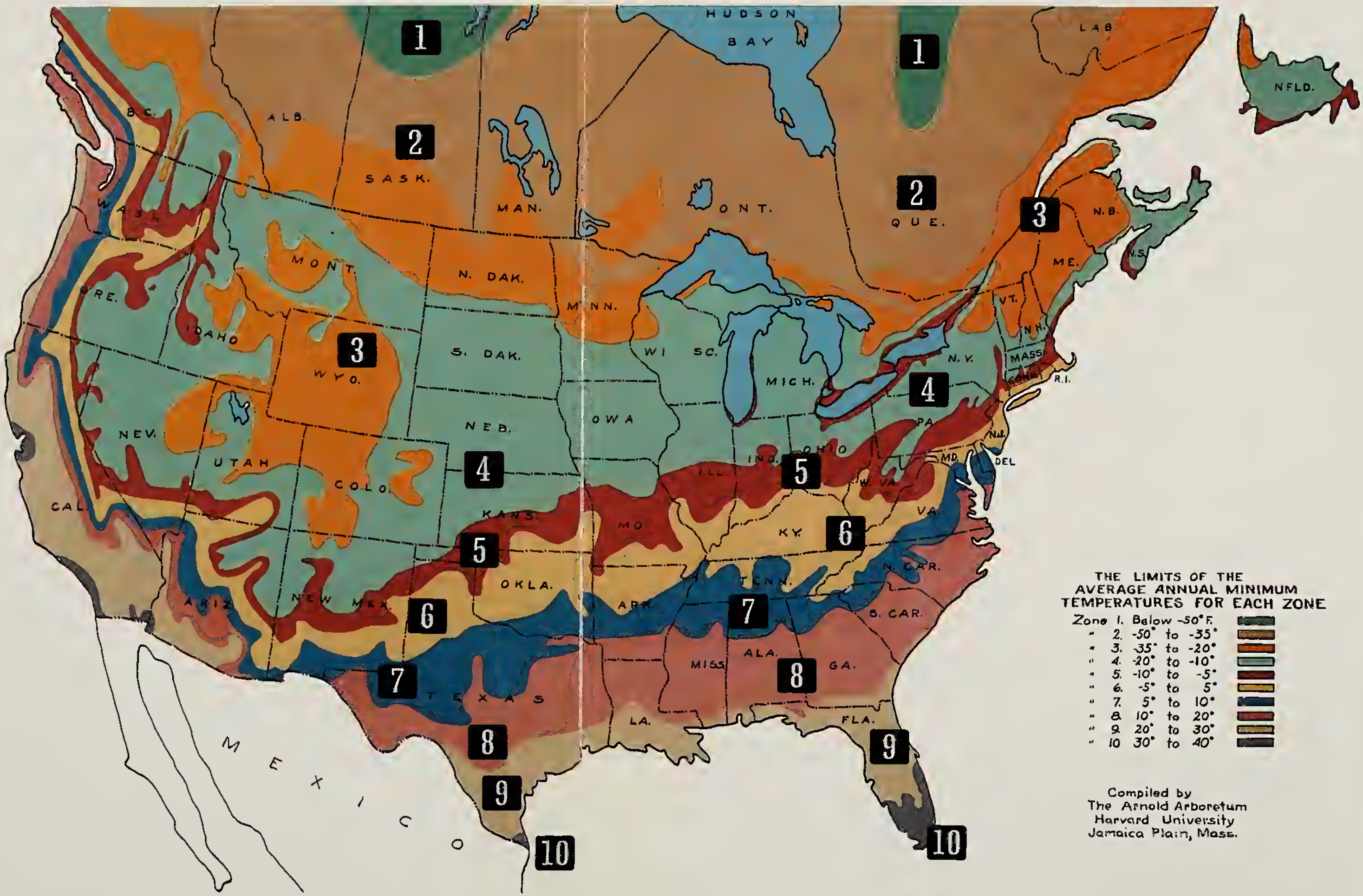
Plant Hardiness Zones in the United States and Canada



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Front cover: The inflorescence and fruits of flowering dogwood (*Cornus florida* L.), top, and of kousa (*C. kousa* Hance), bottom. To find out why kousa has compound fruits and flowering dogwood does not, see page 2. Watercolor by Alice Tangerini, Smithsonian Institution. *Front cover foldout*: Three compound fruits of *Cornus capitata* Wallich, a species of dogwood from the Himalayas. From *Curtis's Botanical Magazine* for 1852. *This page*: Painting by an anonymous Chinese artist of the tree from which Hsueh Chi-ju collected the type specimens of *Metasequoia glyptostroboides* H. H. Hu & Cheng in 1946. (See page 11.) *Inside front cover*: The Arnold Arboretum's Plant Hardiness Zone Map. (See pages 32 through 34.) *Inside back cover*: *Calypso bulbosa* Salisb., an orchid of cool, mossy woods in Canada and the United States. (See page 19.) Photograph by Francis H. Cabot. *Back cover*: Bunchberry (*Cornus canadensis* L.), a small-bracted dwarf cornel with tight clusters of fruits. From *The Monthly Flora, or Botanical Magazine*, Volume I (1846). (See page 2.)

Page

CORNUS NUTTALLII, Aud.

RESEARCH REPORT

The Case for Monkey-Mediated Evolution in Big-Bracted Dogwoods

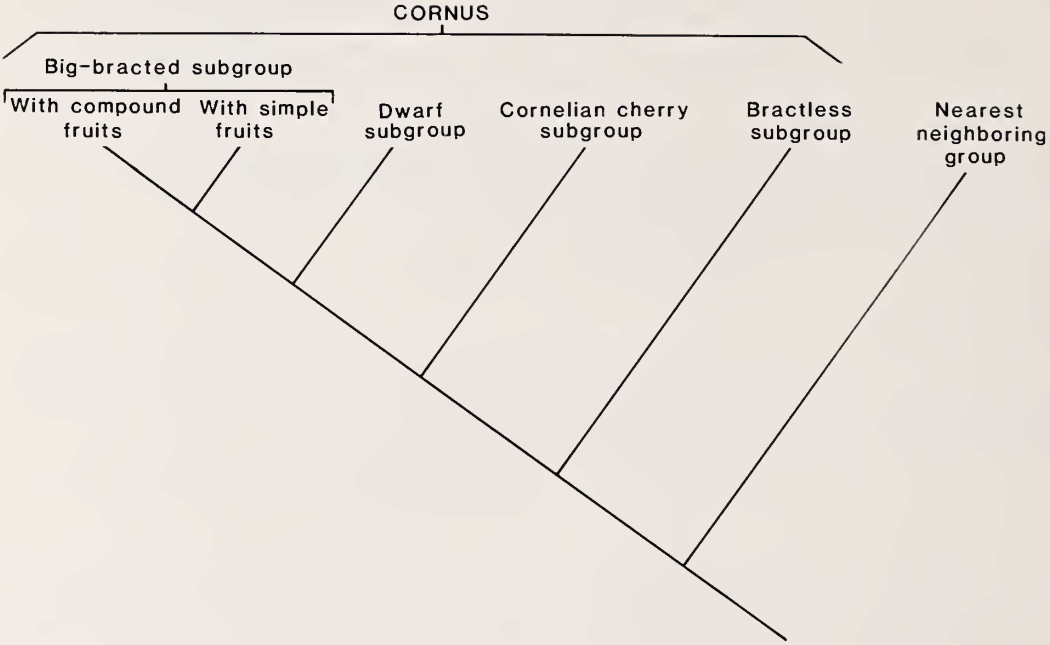
Richard H. Eyde

Because New World monkeys are blind to red and live only in warm regions, American big-bracted dogwoods produce only simple fruits

Say "dogwood" to anyone from eastern North America and the plant that comes to mind is *Cornus florida*, called flowering dogwood because four petal-like bracts beneath each tight flower cluster make a cluster look like one big showy flower. Dogwoods with such blossoms are a minority. Most of the 50-plus species in the dogwood genus—*Cornus* in the wide Linnaean sense—bear broadly branching flower clusters in which bracts are rudimentary or lacking. Dwarf cornels—*C. canadensis* and two similar species—have showy-bracted blossoms and tight clusters, but the bracts, like the plants themselves, are small. Besides *C. florida*, the subgroup with big-bracted clusters includes *C. nuttallii* of western North America and *C. disciflora*, a mountain tree of Mexico and Central America. (The bracts of *C. disciflora* are like those of *C. florida* and *C. nuttallii* only in the bud; they wither and fall off when buds turn into blossoms.) There are big-bracted dogwoods in Asia, too. Of the 19 species recognized in recent treatments (Poyarkova, 1950; Fang, 1953; Hu, 1980; Hu and Soong, 1981), only *C. kousa* is widely known and grown in North America.

Big-bracted dogwoods, American and Asian, had a common evolutionary origin: their chemistry attests to that (Bate-Smith *et al.*, 1975), as do serological experiments (Brunner and Fairbrothers, 1978) and cases of crossbreeding (Orton, 1969; Bean, 1970; Bond, 1984; Santamour and McArdle, 1985). The ease with which they hybridize weighs heavily against the taxonomic splitting of big-bracted dogwoods into two genera, *Dendrobenthamia* and *Cynoxylon*, a practice met with often enough to need condemning.

Though most species of *Cornus* have white, blue, or blue–black fruits, the fruits of showy-bracted species (dwarf cornels included) are red. Fruits of Old World members of the big-bracted subgroup differ from their New World counterparts, however, in that they are compound. [See the cover of this issue of *Arnoldia.*] Our flowering dogwood bears bunched fruits, the individuals parting readily from the bunch: in *C. kousa* and other Asian members of the subgroup, flowers can be separated, but the separability is lost as flowers change to fruits. Ripe compound fruits look enough like fat strawberries that one species, *C. capitata*, is called strawberry dogwood,



The evolutionary relationships among the subgroups of Cornus.

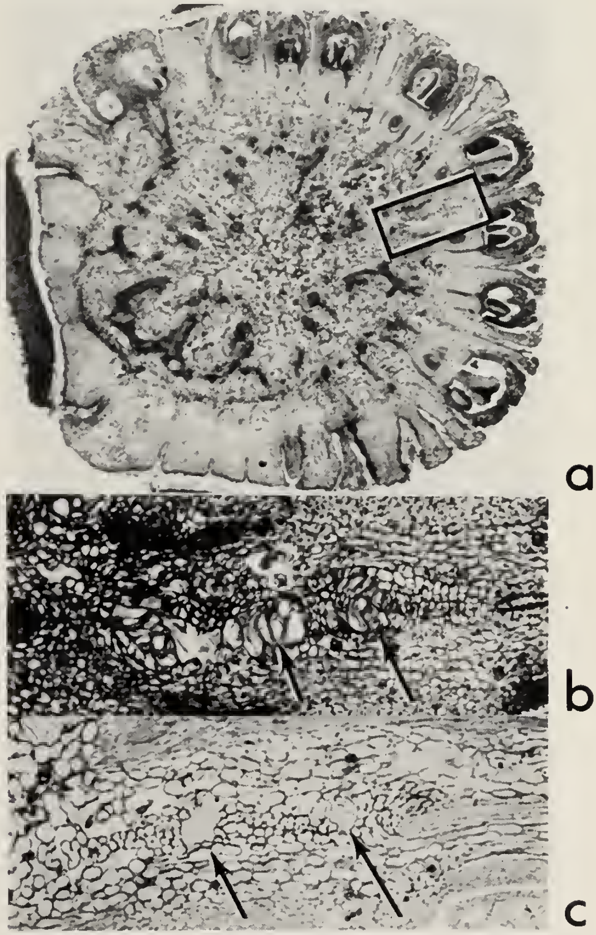
Because compound fruits occur in no genus of the dogwood family but *Cornus*, and there only in the Old World members of one subgroup, students of dogwood evolution can infer with confidence that they are derived. This diagram makes the cornelian cherry subgroup (*Cornus mas* and allied species) more advanced than bractless dogwoods, yet switching these two branches of the diagram would not affect the derived status of compound fruits, and no matter which relative of *Cornus* is chosen as its nearest evolutionary neighbor, the conclusion remains that the change from simple fruits to compound fruits occurred just once, as big-bracted dogwoods separated into today's American and Asian forms.

and the flesh of compound fruits is soft and sweet, unlike the tart or bitter flesh of dogwood fruits in general. [See the front-cover foldout.]

When P. F. Maevskiĭ (1881) examined fruits of *Cornus capitata* microscopically, what he saw misled him. Seeing—he thought—free individuals, each set in a cup-like hollow, he concluded that adjoining fruits do not really unite, that they sink into an expanding fruit stalk as the complex ripens. Museum technician Stan Yankowski and I repeated Maevskiĭ's work with a modern microtome—the anatomist's precise slicer—and a modern microscope, taking pains to look at all stages of growth, and we found true developmental fusion of the ovaries. (Dogwood ovaries are inferior; that is, petals, calyx lobes, and stamens are above the ovary, out of union's way.) Indeed, the stages can be seen at different levels in a half-ripe compound fruit. Stained serial sections through a fused region show normal epidermal cells, one layer for each of the adjoining ovaries, only at the fruit's surface. Within the fruit, the corresponding cells show signs of repeated division. They no longer have their typical rectangular outlines, and they interdigitate: cells from each epidermis penetrate the other. There are, in some places where epidermises once were, nests of the thick-walled, heavily staining cells called sclereids. As the cluster ripens to a sphere roughly half the diameter of a golf ball, tissues tear and cavities develop near the sclereids, hence the illusion of nonunion that Maevskiĭ saw.

Evolutionists from Darwin on have studied the selective pressures that make flowers so diverse, but only recently have they taken note of pressures working on the fruits of temperate regions (Thompson and Willson, 1979; Stiles, 1980, 1982, 1984; Stiles and White, 1982; Morden-Moore and Willson, 1982; Willson, 1983, Borowicz and Stephenson, in press). Thus, evolutionists have overlooked the fact that compound-fruited dogwoods pose the following problem: any reasonable diagram connecting *Cornus* to a neighboring group, and subgroups of *Cornus* to each other, shows that ancestral dogwoods had open flower clusters, that dogwoods with bunched flowers and ordinary fruits came later and gave rise to those with compound fruits. The change to bunched flowers likely had to do with pollinating insects, but the further change to compound fruits must have been dispersal-linked. What new means of dispersal would have made a compound fruit a betterment? And why are dogwoods with such fruits found only in the Old World?

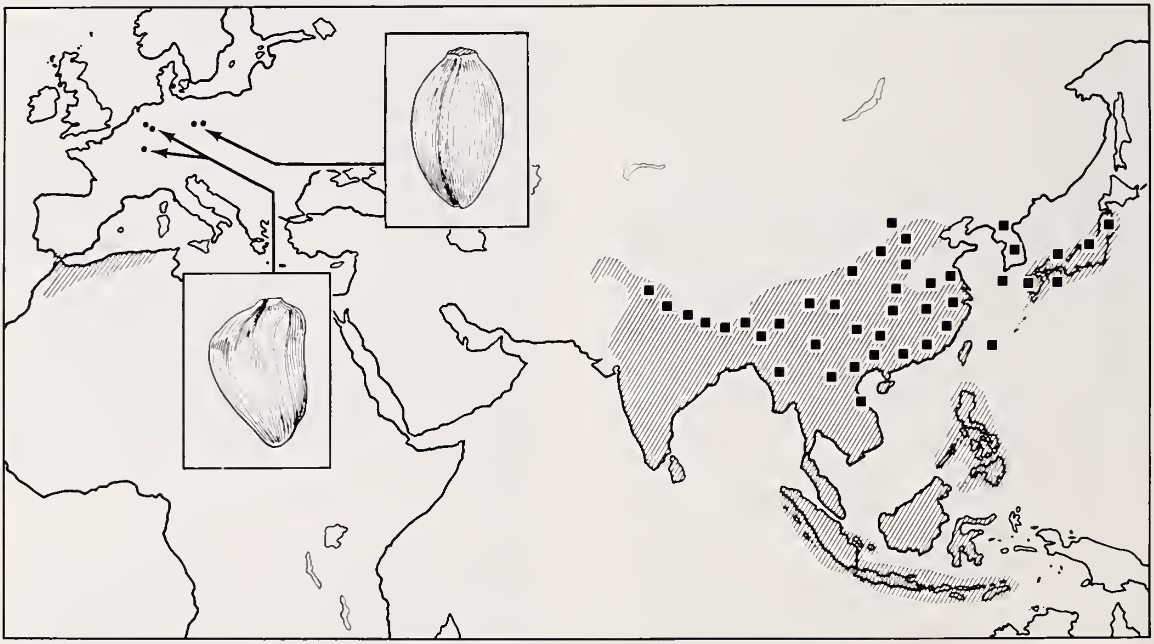
Robins and other migratory birds are the principal dispersers of the flowering dogwood (Baird, 1980). They also peck at fruits of kousa dogwoods introduced to gardens. By tearing up a compound fruit, they doubtless spread some of its seed-containing stones. (As in peaches, inner cell layers of the fruit wall turn into a "stony" housing for the seed. Most dogwoods have two seeds per stone, and a compound fruit has several stones.) But birds the size of robins, which are so well fitted to the bean-sized individual fruits of New World dogwoods, can hardly have provided pressure for the change to compound fruits. Grouse eat dogwood fruits, but tests with quails and pheasants indicate the gallinaceous gizzard does a dogwood stone more harm than good (Krefting and Roe, 1949). In Asia, hornbills and fruit pigeons spread large-fruited plants efficiently, but the birds are tropical, and Asiatic dogwoods, like our own, are largely temperate. Mice, raccoons, and bears disperse some dogwood stones (Martin *et al.*, 1951; Rogers and Applegate, 1983; Borowicz and Stephenson, in press) but not enough to cause an evolutionary change. Furthermore, the beasts are color-blind: the redness of a fruit means nothing to them.



Stained microtome sections of developing Cornus *sp. fruits.*

a: A somewhat oblique slice through the entire fruit of *Cornus capitata*, magnified 11 times. (See the front-cover foldout of this issue of *Arnoldia*.) *b*: The area marked with a rectangle in *a*, enlarged to about 70 times. (Liquid-preserved specimen taken from a wild tree in Nepal [D. H. Nicolson 2371]. *c:* A section like that in *b*, but thinner and from a developing fruit of *Cornus kousa*. (Liquid-preserved specimen from a cultivated dogwood on the grounds of the Smithsonian Institution.) Groups of sclereids (arrows) have differentiated where ovaries have fused.

That leaves monkeys. Monkeys disperse seeds and stones of fleshy fruits by spitting and by voiding (Hladik and Hladik, 1967, 1972; Lieberman *et al.*, 1979). Macaques, the northernmost of monkeys, see color much as human beings do (De Valois and Jacobs, 1968); they eat *Cornus* fruits, both simple and compound (Uehara, 1977; Maruhashi, 1980), and they once ranged almost everywhere within the range of compound-fruited dogwoods. A critic could object that matching the ranges of macaques and dogwoods merely shows that both of them are creatures of the deciduous forest. Taking fossils into account, however, boosts the case for monkey-mediated evolution. Macaque remains are found in the Pliocene and Pleistocene of Asia as far north as Beijing and Korea and at sites in Europe dating back almost to latest Miocene, when macaques are thought to have emerged from Africa (Delson, 1980; Sohn, 1983, 1984*a*, 1984*b*). Lately, European specialists have also learned to spot the remains of dogwood subgroups that have disappeared from Europe. Some of the Miocene impressions once called "persimmon calyxes" are now thought to be the four bracts of *Cornus* (Gregor, 1982), and fossil fruits, when they are well preserved, can be identified more accurately than that. Size, shape, surface features, and internal structure mark a fruit stone as belonging to the big-bracted subgroup. Then, if it is ovoid or ellipsoid, it must be from a solitary fruit like that of *C. florida*. Such stones occur in Oligocene and Miocene brown-coal deposits of the German Democratic Republic (Mai and Walther, 1978). If, however, a stone is asymmetrical, tapered to the base, and faceted, it is from a compound fruit. Only younger beds have yielded



The natural ranges of macaques (hatching) and compound-fruited dogwoods (squares).

Fruit stones like those of flowering dogwood (upper inset) occur as fossils in East Germany; stones from compound-fruited dogwoods occur at younger sites in Alsace and near the Dutch-German border. Compound-fruited dogwoods likely came to some sites—the Ryukyus, for example—with birds or people. Five thousand years of tilling made the blank spot in the Yellow River basin.

The macaque range is from Zhang *et al.* (1981), Fooden (1982), and Wolfheim (1983). The dogwood range is from the Herbarium of the Arnold Arboretum, the Gray Herbarium, the U. S. National Herbarium, and all germane floristic works.

such: a mid-Pliocene locality near Cologne (Burgh, 1978, 1983), another in Alsace (Geissert and Gregor, 1981), and a later Pliocene locality at Tegelen in the Netherlands (Mai, 1976). The Tegelen beds have also yielded bones of a macaque (Schreuder, 1945; see Berggren and Van Couvering, 1979, for information on the age of the Tegelen beds).

Big-bracted dogwoods formerly extended round the Northern Hemisphere, and all had ordinary fruits until monkeys came in contact with them about five million years ago. Selection for a better monkey meal meant better scattering of seeds; so compound fruits replaced the simple ones, but only in Eurasia. America retains the older kind because the New World monkeys, blind to red (Terborgh, 1983) and tied to warmer regions, never took up foraging on dogwoods. The behavioral side of this scenario is testable. China and Japan have monkeys, dogwoods of both kinds (our kind in cultivation), and primatologists to do the testing.

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References

Baird, J. W. 1980. The selection and use 5f fruit by birds in an eastern USA forest. *Wilson Bulletin* **92**: 63–73.

Bate-Smith, E. C., I. K. Ferguson, K. Hutson, S. R. Jensen, B. J. Nielsen, and T. Swain. 1975. Phytochemical interrelationships in the Cornaceae. *Biochemical Systematics and Ecology* **3**: 79–89. [This is an important work for recognizing natural subgroups within *Cornus*, but one conclusion is at odds with my reasoning on dogwood evolution. The authors say hedgingly that *C. capitata*, despite its compound fruits, seems chemically closest to ancestral *Cornus*. I read their data differently in a review I am writing of dogwoods and their allies.]

Bean, W. J. 1970. *Trees and Shrubs Hardy in the British Isles*, 8th edition, Volume 1. London: John Murray. [Page 704 mentions the probable crossing of *Cornus kousa* with *C. nuttallii*.]

Berggren, W. A., and J. A. Van Couvering. 1979. Quaternary. In *Treatise on Invertebrate Paleontology*, Part A, 505–543. Boulder, Colorado, and Lawrence, Kansas: Geological Society of America and University of Kansas Press.

Bond, J. 1984. Some North American dogwoods at Windsor. *The Garden* **109**: 154–155.

Borowicz, V. A., and A. G. Stephenson. In press. Fruit composition and patterns of dispersal of two *Cornus* spp. *Oecologia*.

Brunner, F., and D. E. Fairbrothers. 1978. A comparative serological investigation within the Cornales. *Serological Museum Bulletin* **53**: 2–5.

Burgh, J. van der. 1978. The Pliocene flora of Fortuna–Garsdorf I. Fruits and seeds of angiosperms. *Review of Palaeobotany and Palynology* **26**: 173–211. [Stones that Burgh would recognize in 1983 as those of a compound-fruited dogwood are here called *Carpolithus natans*.]

———. 1983. Allochthonous seed and fruit floras from the Pliocene of the lower Rhine basin. *Review of Palaeobotany and Palynology* **40**: 33–90.

Delson, E. 1980. Fossil macaques, phyletic relationships and a scenario of deployment. In *The Macaques: Studies in Ecology, Behavior and Evolution*, edited by D. G. Lindburg, 10–30. New York: Van Nostrand Reinhold.

De Valois, R. L., and G. H. Jacobs. 1968. Primate color vision. *Science* **162**: 533–540.

Fang, W.-P. 1953. Notes on *Dendrobenthamia*. *Acta Phytotaxonomica Sinica* **2**: 89–114; *plates 11–16.* [In Chinese with English summary.]

Fooden, J. 1982. Ecogeographic segregation of macaque species. *Primates* **23**: 574–579.

Geissert, F., and H.-J. Gregor. 1981. Eine neue Elsässische Pliozän-Flora, die "Saugbagger-Flora" der Kiesgrube von Sessenheim (Bas-Rhin). *Courier Forschungsinstitut Senckenberg* **50**: 59–71. [*Dendrobenthamia tegeliensis* is listed on page 64.]

Gregor, H.-J. 1982. *Die Jungtertiären Floren Süddeutschlands; Paläokarpologie, Phytostratigraphie, Paläoökologie, Paläoklimatologie.* Stuttgart: F. Enke. ["Persimmon sepals" reidentified as dogwood bracts, pages 119–120.]

Hladik, C. M., and A. Hladik. 1967. Observations sur le rôle des primates dans la dissémination des végétaux de la forêt gabonaise. *Biologia Gabonica* **3**: 43–58.

______, and ______. 1972. Disponibilités alimentaires et domaines vitaux des primates à Ceylan. *Terre et Vie* **26**: 149–215.

Hu, W. K. 1980. Materiae ad floram Cornacearum sinicarum. *Sichuan Daxue Xuebao (Ziran Kexue)* [*Journal of Sichuan University, Natural Sciences*] **1980** (3): 155–174. [In Chinese.]

______, and T. P. Soong. 1981. Cornaceae. In *Flora Sichuanica (Spermatophyta)*, edited by Fang W. P., Volume 1, 320–395, 468–475. Chengdu: Chengdu Institute of Biology. [In Chinese.]

Krefting, L. W., and E. I. Roe. 1949. The role of some birds and mammals in seed germination. *Ecological Monographs* **19**: 269–286.

Lieberman, D., J. B. Hall, and M. D. Swaine. 1979. Seed dispersal by baboons in the Shai Hills, Ghana. *Ecology* **60**: 65–75.

Maevskiĭ, P. F. 1881. O stroenii ploda *Benthamia fragifera. Izvestiya Obshchestva Lyubiteleĭ Estestvoznaniya, Antropologii i Etnografii* **37**: 28–30. [Yale University's library has this rarity. *Benthamia fragifera* is *Cornus capitata.* See the front-cover foldout of this issue of *Arnoldia.*]

Mai, D. H. 1976. *Dendrobenthamia tegeliensis* nov. sp.—Ein neues ostasiatisches Florenelement im Altquartär Europas. *Abhandlungen des Staatlichen Museums für Mineralogie und Geologie zu Dresden* **25**: 113–123.

______, and H. Walther. 1978. Die Floren der Haselbacher Serie im Weisselster-Becken (Bezirk Leipzig, DDR). *Abhandlungen des Staatlichen Museums für Mineralogie und Geologie zu Dresden,*Volume 28. [The mid-Oligocene fossils include *Cynoxylon* (*Cornus*) *carolii*, stones like those of modern *C. disciflora, C. florida*, and *C. nuttallii.* Mai, the fruit specialist of the Mai–Walther partnership, also mentions a suggestive similarity of *C. carolii* to Miocene stones that he called simply *Cornus* sp. in his "Die Mastixioideen-Floren im Tertiär der Oberlausitz," *Paläontologische Abhandlungen, Abteilung B, Paläobotanik* **2** (1) (1964). One of the figures in this earlier work—a photo of a *Cornus* stone from Wiesa near Kamenz—is persuasive enough that I added the locality to my map.]

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. *American Wildlife & Plants.* New York: McGraw–Hill.

Maruhashi T. 1980. Feeding behavior and diet of the Japanese monkey (*Macaca fuscata yakui*) on Yakushima Island, Japan. *Primates* **21**: 141–160.

Morden-Moore, A. L., and M. F. Willson. 1982. On the ecological significance of fruit color in *Prunus serotina* and *Rubus occidentalis*: Field experiments. *Canadian Journal of Botany* **60**: 1154–1160.

Orton, E. R., Jr. 1969. Hybridizing woody ornamentals. *International Plant Propagators' Society Combined Proceedings* **19**: 371–375.

Poyarkova, A. I. 1950. Sektsiya Benthamia (Lindl.) nakai roda *Cynoxylon* Raf. i ee vidy. *Botanicheskie Materialy Gerbariya Botanicheskogo Instituta imeni Komarova Akademii Nauk SSSR* **12**: 181–195.

Rogers, L. L., and R. D. Applegate. 1983. Dispersal of fruit seeds by black bears. *Journal of Mammalogy* **64**: 310–311.

Santamour, F. S., Jr., and A. J. McArdle. 1985. Cultivar checklists of the large-bracted dogwoods: *Cornus florida, C. kousa*, and *C. nuttallii. Journal of Arboriculture* **11**: 29–36.

Schreuder, A. 1945. The Tegelen fauna, with a description of new remains of its rare components (*Leptobos, Archidiskos meridionalis, Macaca, Sus strozzii*). *Archives Néerlandaises de Zoologie* **7**: 153–204.

Sohn, P. 1983. *Early Man at Turubong Cave No. 9 near Ch'ongju, Korea.* Seoul: Laboratory of Prehistory, Museum of Yonsei University. [In Korean with English summary.]

______. 1984*a*. Early man in Korea. *East Asian Tertiary/Quaternary Newsletter* **1**: 61–62.

______. 1984*b*. The palaeoenvironment of Middle and Upper Pleistocene Korea. In *The Evolution of the East Asian Environment*, edited by R. O. Whyte, Volume 2, 877–893. Hong Kong: Centre of Asian Studies, University of Hong Kong.

Stiles, E. W. 1980. Patterns of fruit presentation and seed dispersal in bird-disseminated woody plants in the eastern deciduous forest. *American Naturalist* **116**: 670–688.

______. 1982. Fruit flags: Two hypotheses. *American Naturalist* **120**: 500–509.

______. 1984. Fruit for all seasons. *Natural History* **93** (8): 42–53.

______, and D. W. White. 1982. Additional information on temperate bird-disseminated fruits: Response to Herrera's comments. *American Naturalist* **120**: 823–827.

Terborgh, J. 1983. *Five New World Primates: A Study in Comparative Ecology.* Princeton: Princeton University Press. [Page 77 treats vision and fructivory.]

Thompson, J. N., and M. F. Willson, 1979. Evolution of temperate fruit/bird interactions: Phenological strategies. *Evolution* **33**: 973–982.

Uehara, S. 1977. A biogeographic study of adaptation of Japanese monkeys with regard to food habits. In *Keishitsu, Shinka Reichorui* [*Morphology, Evolution, and Primates*], edited by Y. Kato, S. Nakao, and T. Umesao, pages 187–232. Tokyo: Chuokoron-sha. [In Japanese.]

Willson, M. F. 1983. *Plant Reproductive Ecology.* New York: Wiley.

Wolfheim, J. H. 1983. *Primates of the World.* Seattle: University of Washington Press.

Zhang, Y. Z., S. Wang, and G. Q. Quan, 1981. On the geographical distribution of primates in China. *Journal of Human Evolution* **10**: 215–226.

Richard H. Eyde is curator in the Department of Botany, Smithsonian Institution, Washington, D.C.

Professor Hsueh Chi-ju, the botanist who collected the type specimens of Metasequoia glyptostroboides *in 1946. Photographed in October 1984 by Peter S. Ashton.*

Reminiscences of Collecting the Type Specimens of *Metasequoia glyptostroboides* H. H. Hu & Cheng

Hsueh Chi-ju

After forty years a Chinese botanist has still-vivid memories of his eager and determined quest for specimens of the dawn redwood

When the Arboretum's Director, Peter S. Ashton, visited the People's Republic of China during the fall of 1984, he met Professor Hsueh Chi-ju, of Southwestern Forestry College, Kunming City, Yunnan province. As a young man, Professor Hsueh had collected the type specimens of the recently discovered dawn redwood, Metasequoia glyptostroboides *H. H. Hu & Cheng. Director Ashton invited him to write a first-hand account of his collecting trips, for publication in* Arnoldia. *To commemorate the approaching forty-fifth anniversary of the discovery of living* Metasequoia *trees, we are pleased to present herewith Professor Hsueh's fascinating account of his adventures.*

Forty years ago, I happened to see the specimen of *Metasequoia glyptostroboides* that Mr. Wang Zhang had collected at Modaoqi [knife-grinding] village in Wanxian county, China. The next year, following the route Mr. Wang had taken, I made two trips there to collect perfect specimens and to conduct further investigations. Although I am old now, the two trips are still fresh in my memory.

I graduated from the Forestry Department of the former National Central University at Zhongjing (Chungking) in 1945 and then worked on the gymnosperms, studying for a master's degree under the guidance of Professor Cheng Wanjun. One day in 1945, Wang Zhang, who worked at the Central Forestry Experimental Institute, sent a cone-bearing specimen collected at Modaoqi to Professor Cheng for identification. Its vernacular name was *shui-shan* (water fir), and it was somewhat similar to *Glyptostrobus pensilis* (*G. lineatus*). After making a preliminary identification, Professor Cheng considered that it might belong to a new taxon of the Gymnospermae, since the opposite arrangement of the leaves and cone scales differed from that of *G. pensilis* and other members of the Taxodiaceae.

Since the specimen Mr. Wang collected had no male inflorescences and since the cones had been picked up from the ground, we didn't know how the cones grew on the branches. In addition, we had no information on whether it was deciduous or evergreen, on its flowering season, or on its ecological characteristics and distribution.

Further research being necessary, Professor Cheng naturally advised me to collect some perfect specimens and to make an investigation. Since we had no funds and everybody was quite hard up, I could only go to the place on my own, carrying a few pieces of simple baggage and specimen-clips. I left Chungking city by streamboat and, after two days, arrived at Wanxian county, on the northern bank of the Changjiang (Yangtze) River. After crossing the river, I had to walk 120 kilometers [72 miles] to my destination. In 1946 I made two trips from Chungking to

Topography of the rugged region of central China in which the author travelled, often by narrow mountain trails, in his search for Metasequoia *trees, as photographed from a NASA satellite in 1975. He collected the type specimens from a tree just outside Modaoqi. The irregular white areas are snow-covered mountain ranges. The population of trees Professor Hsueh was looking for when his time ran out, and he had to return to Wanxian, is labelled "Metasequoia Valley." The approximate range of* Metasequoia *is the hatched area bounded by triangles.*

Modaoqi, in February and May, respectively, both times single-handedly.

The First Trip to Modaoqi

I remember that on my first trip the boat was moored in Fengdu county for the first night. On a hill behind the county town was a temple regarded in the Old China as an inferno where the "Lord of Hell" reigned. Dead souls were supposed to go there to register. So I made use of this rare opportunity to take a solitary night walk in this weird and dreadful place—evidence that I was full of vigor and curiosity in my youth.

At that time there was no highway from Wanxian county to Modaoqi village. My trip was very difficult, the trails threading through the mountains being less than one foot wide. The region was inhabited by the Tu minority and had been isolated from the outside world for ages. During the war of resistance against Japan, the Hubei provincial government moved to Enshi county in its neighborhood; thenceforward its intercourse with the outside world had somewhat increased. Since this region was located on the border between Sichuan and Hubei provinces, an area characterized by difficult and hazardous roads, murder and robbery occurred frequently. It was regarded as a forbidding place and was seldom visited by travellers.

On my trip, I set out from Wanxian and stayed at Changtanjing for the night. My fellow travellers were several pedlars. While we chatted around a fire at night, the innkeeper came to give us a warning: "If you go any farther you will travel along a narrow valley cut by the Modaoqi River. Travel will become more dangerous and threatened with robbery, which often occurs at dangerous turns of the river. Travellers from both directions are robbed by being jammed together, or 'rounded up.' Therefore, if you see no travellers coming your way for a long time, it is very likely that a robbery has occurred ahead, and you had better take care. Only a few days ago we witnessed such an incident in this vicinity." The innkeeper then gave a vivid and horrible description of a murder. The poor pedlars, my fellow travellers, were very frightened. They dared not go any farther and returned to Wanxian the next morning. As for me, I was bent on finding that colossal tree and collecting more specimens, so I resolutely continued my trip along the route marked out by Mr. Wang, without any fear or hesitation.

Finally, at dusk on the third day, I reached my destination safely. I set out immediately to search for that colossal tree despite hunger, thirst, and fatigue, and without considering where I would take my lodging. It was February 19th, and cold. The tree was located at the edge of the southern end of a small street. In the twilight nothing was discernible except the withered and yellowed appearance of the whole tree. My excitement cooled.

"Am I to bring back just some dried branches?" I asked myself.

The tree was gigantic; no one could have climbed it. As I had no specific tools, I could only throw stones at it. When the branches fell from the tree, I found, to my great surprise, that there were many yellow male cones and some female cones on the leafless branches. I jumped with joy and excitement.

The city of Wanxian, looking downstream along the Changjiang (Yangtze) River. All of the expeditions to the Metasequoia *region began in this bustling port situated over 900 miles from the river's mouth. Photograph by the American members of the 1980 Sino-American Botanical Expedition (B. Bartholomew, D. E. Boufford, J. L. Luteyn, and S. A. Spongberg).*

The weather being cold, many plants were not yet in flower. Since I was short of money, I returned to Chungking city three days later.

The Second Trip to Modaoqi

The second trip was in May of the same year, its purpose being to collect the cone-bearing specimens in addition to ascertaining the natural distribution of *Metasequoia* and the flora of the region. On my way to Modaoqi, about half a day's walk from my destination, I came across a peasant carrying a bundle of fagot mixed with some *Podocarpus nagi*. The wood was said to have been cut from a nearby mountain. I took two twigs and pressed them as specimens. This indicated that *P. nagi*, another primeval gymnosperm, occurred in the vicintiy.

The tree in Modaoqi from which the author collected the type specimens of Metasequoia glyptostroboides. *The shrine he mentions has been dismantled but is shown in the drawing on page 1 of this issue of* Arnoldia. *Photograph by the American members of the 1980 Sino-American Botanical Expedition.*

This time I took measurement of the *Metasequoia* tree. It was 37 meters [about 122 feet] high and 7 meters [about 23 feet] in girth, and still grew vigorously.

To ascertain the distribution of *Metasequoia* I interviewed many local people, but none of them knew. The innkeeper did tell me that a whole stretch of *shui-shan* trees might be found at Xiahoe, in Lichuan county, Hubei province, about 50 kilometers [30 miles] away. As I had almost exhausted my travelling allowance, and as communication was extremely inconvenient, I had to give up my attempt to extend my trip to that place. Nevertheless, the innkeeper had provided an important clue for a more thoroughgoing exploration later. All I could do was—taking the original spot as a center—to make a reconnaissance within the area I could cover in one day. In a few days I had collected more than one hundred specimens.

Two things impressed me deeply. One was that I came across whole stretches of *Geastrum* sp. (an earthstar fungus) mixed with small stones of a similar shape, forming a peculiar landscape. The other thing that impressed me was an incident. Not even by the day before my departure had I given up on the possibility of making a reconnaissance. At four in the afternoon of the last day, I met a traveller coming from the southeast and asked him where the *shui-shan* tree could be found. He told me that it could be got near a small village about 5 kilometers [3 miles] from where we were. Upon hearing this I almost broke into a run, intending to return to the inn before dark so that I might leave for Wanxian the next day. After trotting for a while, I met another peasant and asked him how far it was to the village. (I can't be sure now, but it may have been Nanpin village in Lichuan county.) "Five kilometers," he replied. Mountain people sometimes differ considerably in their gauge of distance.

I was wavering as to whether to go or not. If I should go, it was certain that I could not have returned to the inn before dark and that the innkeeper would worry. Then, too, I had already hired a man to carry the specimens for me; we had agreed on the next morning as the time for departure. I could not break my word! But finally I made up my mind to make another reconnaissance for *shui-shan*.

It was getting dark when I arrived at the small village. The villagers in their isolation seldom met outsiders, especially "intellectuals" such as I was. My arrival aroused their curiosity. They surrounded me, making all sorts of inquiries. But I was anxious to see the *Metasequoia* trees. When I was told that there were no such trees, I was very disappointed. However, I did not give up hope, and asked the villagers to accompany me to make one last reconnaissance. There was, indeed, no *Metasequoia*. I did collect some specimens of *Tsuga chinensis*, however.

I intended to return to the inn in spite of the dark night. However, the friendly villagers had already made arrangements for my food and lodging, and had warned me repeat-

Male cone (left) and female cones of Metasequoia glyptostroboides. *The author made his trips to secure male as well as female cones so that the new species could be given a botanical description. Photographs by LeRoy C. Johnson.*

"Metasequoia Valley," near Xiahoe, in 1980. Note the absence of natural vegetation around the conspicuous Metasequoia *trees. Photograph by the American members of the 1980 Sino-American Botanical Expedition.*

Drawing, by an unknown artist, of a 420-year-old Metasequoia *tree in "Metasequoia Valley," Xiahoe commune. This is the oldest* Metasequoia *tree known.*

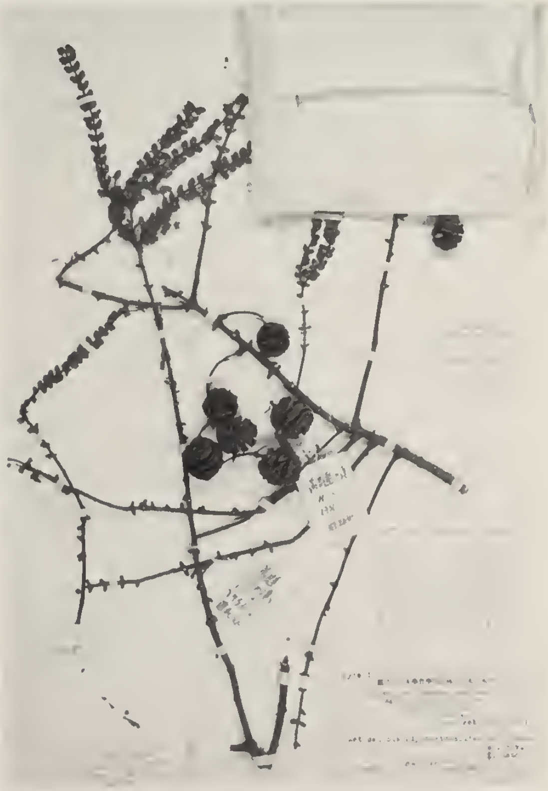
edly of the frequent robberies on the way, insisting on my leaving the next day, escorted by some local people. Yet I could hardly fall asleep, thinking that I could not cause them so much trouble or break my word to the hired carrier. And then I thought that in the depth of the night there would be no "bandits," since there would be no travellers to rob. So, at two in the morning I awoke my roommates, explaining to them the reason for my prompt departure, and left the villagers a letter of acknowledgment. Since the door was locked, I could only jump over the wall so as not to disturb others. In the moonlight I passed through stretches of dark pines, returning to the inn before dawn. That very day I left for Wanxian.

Geomancy Spared the Type Tree

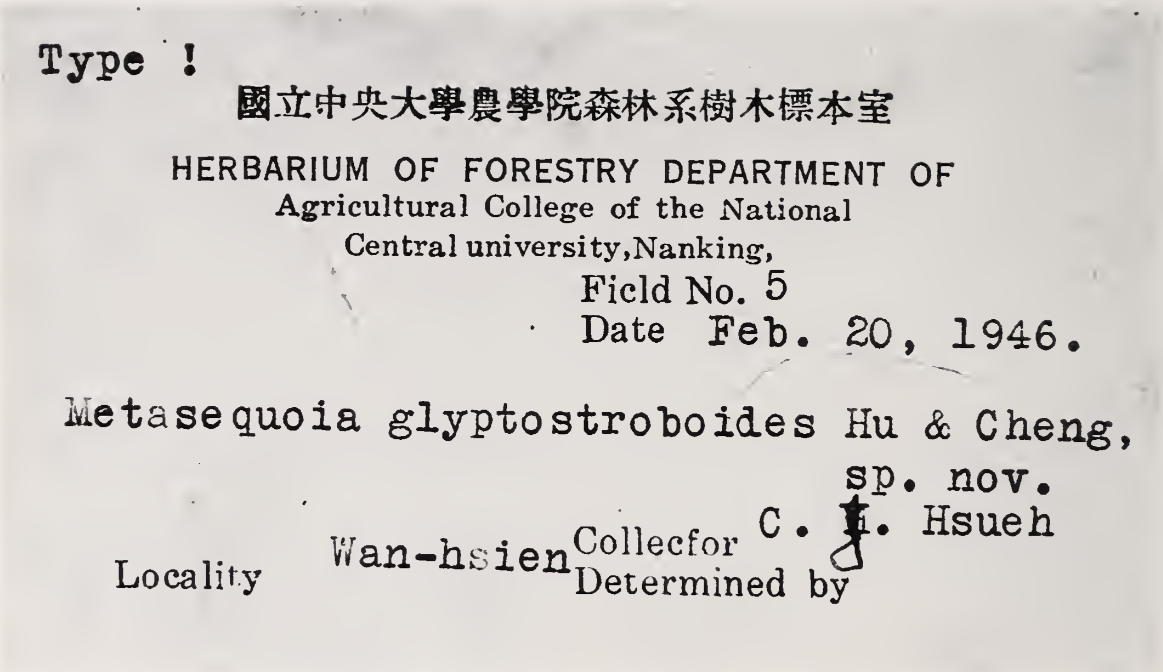
Modaoqi was a very small village, to the southeast of which stood the Chiyue Mountains. Its altitude was 1,744 meters [about 5,755 feet]. At the time it was in Wanxian county, Sichuan province. It was so called because of its situation at the source of the river. As *modao* in Chinese means "knife-grinding" and suggests sinisterness, the name was changed to Moudao, which means "truth-seeking" in Chinese. At present it is under the jurisdiction of Lichuan county, Hubei province.

As the local people looked upon the *Metasequoia* as a sort of divine tree, they built a shrine beside it. Among the villagers there were quite a few traditions about the *Metasequoia*. As a result, the villagers considered its fruit-bearing condition to be an indication of the yield of crops, and the withering of its twigs or branches a forecast of someone's death. It was also rumored that, some time after the founding of the Kuomin Tang government, some foreign missionaries who were passing through the village were willing to buy the tree for a big sum of money. The villagers refused to sell, however, because of the geomantic nature of the place. Thus, it was because of feudalistic superstition that the tree had survived. Its age is estimated at four hundred years.

With the advent of well regulated highway communication, the poor village of the former days changed its aspect long ago. The *Metasequoia* tree, which had survived the ravages of time and is reputed to be a "living fossil," has not only persisted, but is being disseminated. Now, *Metasequoia* trees are "settled" in many countries of the world. It is only natural that people, when admiring this species of primeval tree, should wonder about its original habitat and should wish to know how it was discovered.



The prize: one of the many specimens of Metasequoia glyptostroboides *that Professor Hsueh collected during his first trip to Modaoqi. This specimen, called a syntype, is in the Herbarium of the Arnold Arboretum. Photograph by David E. Boufford.* *See next page.*


Type !

國立中央大學農學院森林系樹木標本室

HERBARIUM OF FORESTRY DEPARTMENT OF
Agricultural College of the National
Central university,Nanking,

Ficld No. 5
Date Feb. 20, 1946.

Metasequoia glyptostroboides Hu & Cheng,
sp. nov.

Locality Wan-hsien Collecfor C. J. Hsueh
Determined by

Metasequoia was discovered in 1941 at Modaoqi in Sichuan Province near the border with Hubei Province by T. Kan (Gan Duo), of the Department of Forestry of National Central University. Kan, however, did not collect or make specimens, and it was not until 1943 that C. Wang (Wang Zhang) of the Central Bureau of Forestry made the first collections of herbarium material. The tree was initially thought to be a form of *Glyptostrobus lineatus* (Poiret) Drude (syn.: *G. pensilis* (Staunton) Koch), but W. C. Cheng (Cheng Wanjun), of National Central University in Nanjing, realized that it represented a new genus. As a result, Cheng sent one of his assistants, C. J. Hsueh (Xue Jiru), to collect more herbarium material in February and May of 1946. In the fall of 1946, H. H. Hu (Hu Xiansu), then director of the Fan Memorial Institute of Biology, Beijing, received material from W. C. Cheng. Hu recognized that the newly discovered tree belonged to the genus *Metasequoia*, described in 1941 from Pliocene fossils by the Japanese botanist Shigeru Miki. Miki determined that certain fossils, which for nearly 100 years had been variously assigned to either *Sequoia* or *Taxodium*, actually represented a new genus, which he named *Metasequoia*. At the time, he did not realize that a living species of *Metasequoia* was still extant in south-central China.

—Reprinted from an article by Bruce Bartholomew, David E. Boufford, and Stephen A. Spongberg in the *Journal of the Arnold Arboretum*, vol. 64, no. 1 (1983). Used with permission.

"Les Quatre Vents," a Far-Northern Garden

Francis H. Cabot

Seizing opportunities presented by cool, moist summers and deep winter snows has been the key to success in this northern outpost of Zone 4

A detailed map of the plant-hardiness zones of North America shows Zone 4 sweeping east from Lake Superior to the northern-tier states of New York and New England, thence north through New Brunswick to Newfoundland. As one follows the St. Lawrence River northeast from Montréal, Zone 4 appears to peter out on the north shore of the river a few miles north of the windswept Citadel of Québec City, which overlooks the river at a point where it suddenly changes into an ever-widening inland sea that ultimately, seven hundred miles to the northeast, becomes the Atlantic Ocean. The view to the northeast from the heights of Québec over the thirty-mile-long Île d'Orléans shows the southern shore of the St. Lawrence receding into the distance as it veers slightly to the east. The view of the north shore, on the other hand, is limited by Cap Tourmente, a stark, eighteen hundred-foot-high headland that curves sharply down to the roiled gray–green salt water. At this point, just beyond the northern tip of Île d'Orléans, the granite mass of the Laurentian Mountains, clothed in the spruce and fir mantle of the boreal forest, meets the salt-water coastline for the first time. From here on, these two elements—boreal forest and salt water—are the norm until one reaches the tundra and permafrost of Labrador. They dominate the ecological and horticultural life of the region.

In the following article, Francis H. Cabot, who has been gardening in a small, far-northern outpost of Hardiness Zone 4, shares the horticultural insights he has gained over the course of the past twenty years.

The departure of the greater snow geese in late May and their return in early October have special significance at La Malbaie, Charlevoix County, Québec, for their migration flights bracket precisely La Malbaie's gardening season, which is seven or eight weeks shorter than those of zones 5 and 6. For six weeks each spring, the great flock stops to feed on the sedge *Scirpus americanus* that grows along the brackish marshes of the St. Lawrence River to the south of Cap Tourmente. The flock, now estimated to number over 250,000, thanks to its protected status, makes only this one stop in its 2,500-mile journey from the coasts of Delaware and North Carolina to its breeding grounds on Ellesmere and Baffin islands. The seven hundred-mile flight from the Middle Atlantic coast lasts two hundred hours. No one knows how long the second leg of the flight, from Cap Tourmente to Baffin Island, lasts.

Virtually the last farming area of any size along the northern shore of the St. Lawrence, La Malbaie, thanks to the tempering effect of its fourteen-mile-wide stretch of the river,

Overleaf: *Part of the terraced vegetable garden at "Les Quatre Vents." The beds were constructed from trees killed by the spruce budworm. Potatoes grow in the bed in the foreground. The bed in the center contains sweet peas, that at the left, red currants. All photographs are by the author.*

Astilbe, delphiniums, Cimicifuga racemosa, *and* Achillea taygetea *in the perennial border.*

Allium christophii *(center),* Primula florindae, P. alpicola *var.* luna, Lilium martagon *var.* album, *and* Meconopsis betonicifolia *in bloom in shade garden Bed No. 3, with astilbe and* Aruncus dioicus *in the bed in the background.*

enjoys a microclimate of Zone 4 in an area of some twenty-five square miles surrounded by a relatively thin band of Zone 3 that soon becomes Zone 2. In the best of years La Malbaie enjoys both the cool summer evenings and the fog and mists of a maritime climate (its portion of the St. Lawrence warms to 48 degrees Fahrenheit in late summer), as well as the deep early snows of the boreal forest. If the snows arrive before the ground freezes and last throughout the winter, the horticulturist can proudly display plants that usually thrive only in the Himalayas or in Scotland. In the worst of years, when the snows don't come until it is too late, or even when an atypical winter thaw destroys the snow cover, it is another story, and a humbler horticultural outlook prevails. Most years the results are in between and are horticulturally satisfying.

Limitations to Northern Gardening

The principal drawback to gardening in northern zones is the limited choice one has of trees and shrubs, yet this limitation does simplify the landscaper's task. At La Malbaie the wisest course often has been to use native (or naturalized) species for the backbone of the landscape plan. On the whole, the native species are a useful and appealing lot.

The conifers are represented by the spruces *Picea abies*, *P. glauca*, and *P. nigra*; the balsam fir (*Abies balsamea*); the American larch (*Larix laricina*); and the pines *Pinus strobus*, *P. resinosa*, and *P. banksiana*. *Thuja occidentalis* thrives near the shores of the St. Lawrence, growing to majestic proportions, and *Juniperus communis* var. *depressa* abounds. There are a few shoreline specimens of *Juniperus horizontalis*, and *Taxus canadensis* is prevalent in the forest.

Sorbus americana, the mountain ash, is everywhere, enlivening the late-summer and autumn landscape with its abundant clumps of red berries. There are groves and hillsides of the quaking aspen (*Populus tremuloides*), which the French Canadians call *les trembles*, and several kinds of *Amelanchier*, whose burnished-orange autumn foliage complements the tints of the red and sugar maples. *Acer spicatum*, the ubiquitous mountain maple, needs to be constantly weeded out of woodland areas, and *A. pensylvanicum* (moosewood) to be encouraged.

While *Betula lutea* (yellow birch) can be found in the forests, far and away the best of the native trees is *Betula papyrifera*, the paper birch. Invariably decorative at all stages of its life, the paper birch enchances its surroundings whether it is used as a lawn specimen, in the garden, or as an allée. I cannot decide whether its bark is more beautiful in early youth, when it has fawn-like spots; in adolescence, when it develops coral and peach tints; or in maturity, when it takes on a pristine whiteness. In this northern setting the paper birch seems to be whiter than it is farther south and is hard to improve upon in the landscape.

Many non-native species love the North also. The Lombardy poplar (*Populus nigra* 'Italica') achieves impressive heights at La Malbaie, for example, as does the Carolina poplar (*P. canadensis*). The former's relatively short life span and pruning needs at maturity give one pause, however, but, used as an accent or as a specimen, there is nothing quite so effective or so appropriate for French Canada. The Carolina poplar is far less demanding, it would appear, and longer lived. Undistinguished in its early years, the Carolina poplar achieves dignity and grace with age and can be a useful part of the landscape.

The Amur maple (*Acer ginnala*), the earliest maple to take on color in the autumn, is also useful. Hardy to Zone 2, it forms a graceful, medium-sized tree but requires pruning and thinning as it matures. It is worth the trouble, though, for its brilliant scarlet foliage in September. Along one of the farm roads we have planted an allée of Amur maple that is becoming increasingly colorful as the years pass.

While a few of the hardier species of *Malus* can withstand the winter temperatures of Zone 4, the diversity of blossom color available in Zone 5 and points south is missing, as are the flowering cherries. Apple trees are close to their northern limits at La Malbaie. They grow very slowly there, but it is worth the wait for their crisp and flavorful fruit. 'Fameuse' is one of our favorite varieties. Plums do beautifully at La Malbaie and seem healthier and more productive there than they do in more-southern climes. Our crop of 'Mirabelle' and other small varieties of plum is abundant.

The Zone 3 and Zone 4 climatic limitations on trees are felt equally severely among shrubs, but there are sufficient species of *Rosa, Syringa, Spiraea, Berberis, Viburnum, Philadelphus, Neillia, Lonicera, Caragana, Cornus,* and the like to make do and to furnish the garden adequately.

It is when one comes to herbaceous plants that one forgets about the lack of diversity in trees and shrubs and begins to chortle over the salubrious northern maritime climate. Aside from the Pacific Northwest, it has to be the best spot on the continent to raise perennials. While the Atlantic coast from Maine north shares a comparably cool and damp summer climate, it does not enjoy the heavy snow cover that is characteristic of the Laurentians.

The sensible gardener at some point stops fighting his climatic limitations and sticks to what will do well for him in the habitats and microclimates that he is able to create. The joy of gardening in a northern maritime garden is that it widens his horizons considerably. Of course, those plants that depend on heat units to live up to their promise will not fare so well. But then life is a series of compromises; the gardener will have to choose between the delights of harvesting sweet corn and raising exotic primulas.

A Botanical Ramble in the Boreal Forest

An English friend of mine, walking through the woodlands surrounding the gardens at La Malbaie, was struck by the number of great botanists and plant hunters who were commemorated in the flora. Not only the great Linnaeus in the twinflower (*Linnaea borealis*) that carpets the woodlands, but John Goodyer in the three species of *Goodyera* that abound (*Goodyera oblongifolia, G. repens*, and *G. tesselata*), Sir Joseph Banks in the stands of *Pinus banksiana*, and John Bartram in the serviceberry, *Amelanchier bartramiana*.

The serviceberries are edible but not particularly interesting. The best of the lot are the oval fruits of *Amelanchier bartramiana*, which are larger and more succulent than other varieties. It seems strange that this most garden-worthy species, which is found in the Laurentians and at the higher elevations of the Appalachians, is not more widely used in horticulture. The white flowers are the largest of the genus, comparable to those of *Potentilla fruticosa* and borne in a very similar fashion. The leaves, as they emerge in the spring, vary from bronze to pale green and turn to burnished orange in late September. *Amelanchier bartramiana* is a shrub rather than a small tree. It grows slowly, attaining a maximum height of five to six feet, and is compact and stoloniferous. The largest specimen I have seen was five feet in diameter and had a most sympathetic and slightly irregular outline such as one finds in specimens of ancient English box. Why, then, is it not proffered by the trade?

The answer lies in the propagation records of the Arnold Arboretum, which show that every effort to propagate *Amelanchier bartramiana* from seed or cuttings over the years has failed. It can be introduced successfully into the garden by transplanting small, stoloniferous offshoots severed from the main root in early spring. Princeton Nur-

Peonies, thalictrum, Amsonia tabernaemontana, *and* Aruncus dioicus *line the Goose Allée. The hedge is hawthorn.*

series has successfully grafted bud-wood of branches cut in the autumn to scions of *Amelanchier canadensis*, and it should be propagable from root cuttings, given its stoloniferous nature. [Alfred J. Fordham describes the technique for doing so in *Arnoldia*, volume 28, numbers 4 and 5 (May 17, 1968), pages 36 to 40]. I hope it will find its way into more widespread horticultural use.

Gustatory Delights of the Boreal Forest

A botanical ramble through the boreal forest in late summer has many gustatory rewards as well. One can nibble the tiny, delicious, and fragrant creeping snowberry (*Chiogenes* [or *Gaultheria*] *hispidula*), and the *noisette* (*Corylus americana*), the local hazelnut. One can bring home baskets of mushrooms: chanterelles, cepes, russulas, clavarias, coprinuses, puffballs, and a wonderful nutty-flavored, bright-orange parasitic fungus, *Hyphomyces lactifluorum*. An experienced mycologist could probably identify scores of other edible varieties among the hundreds that proliferate in the woods. We are slowly expanding the repertoire, and cautiously, too, for there is little room for error.

In July, August, and September our every spare moment is taken up with the harvesting and preserving of berries, from the delectable *fraises des champs* (so far superior to the *fraises des bois* of France), through all the garden varieties of strawberries, raspberries, gooseberries, and currants to the lowbush blueberries (*Vaccinium angustifolium*). Berries, in general, have a superlative flavor and spoil one for their counterparts down south.

If one hikes to the higher elevations of the Laurentians one finds *Rubus chamaemorus*, the exotic, buff-colored cloudberry, so prized by the Scandinavians, along with mountaintops of the brilliant, scarlet mountain cranberry (*Vaccinium vitis-idaea* var. *minus*), the lingonberry of Sweden and the *Preisselbeeren* of Germany. The French call them *airelles rouges*, and the local Indians call them *ataca*. Whatever they are called, they make the best of all tart preserves to accompany game, and their glossy, dark-green, prostrate mats are an exhilarating sight, particularly when they are interspersed with shrubby *Cladonia* lichens in the cracks of a lichen-covered rock—the perfect setting for the scarlet berries. Inedible or less-edible berries abound as well: the gray–blue of *Vaccinium uliginosum* var. *alpinum*, *Empetrum nigrum*, the black and dark-purple crowberry, and, of course, the bright-red bunchberry (*Cornus canadensis*), which sheets the ground in the right habitats.

Developing a Cultivated Landscape at La Malbaie

Our garden and house were built over the past sixty years on a part of a *seigniory* granted in 1653 by Louis XIV to Jean Bourdon, Surveyor General of the Colony of New France. The lay of the land has dictated the development of the landscape from quite modest beginnings to a series of gardens that now cover approximately twenty acres. The cultivated landscape is still growing somewhat but is approaching its logical limits. The growth and development of the garden make interesting study, especially because no professional landscaping expertise has been brought to bear on the matter. In 1926, a house was built in a bare field and a small perennial garden created to the west, where the view leads over a meadow, across a stream-filled gully, to pastures, distant woodlands, and the muted cordillera of the Laurentians. A steep, wooded hillside that merges into sloping pastures marks the northern flank of the setting. To the south one looks down across the bay of La Malbaie to the villages on the far shore.

We use *Pinus sylvestris*, *P. cembra*, and *P. mugo* extensively, and *Tsuga canadensis* (Canada hemlock) can be established in sheltered spots. Other conifers grow well, although we have not tried a wide variety of species, probably because the surrounding forests are of spruce and fir. It would be interesting to establish an experimental planting of conifers to determine which of them would grow. Unfortunately, nurseries in Québec have a limited number of species from which to choose. *Thuja* is invaluable for hedging and shaping, as is the local *Crataegus*, *C. foetida*. The native species can easily be dug from the surrounding woodlands and incorporated into the landscape plan. There is ample material with which to create a framework and background that fits in well with the natural setting.

An entrance allée of Lombardy poplars planted in 1926 is now in its last stages of decay. What was once a dramatic feature of the landscape has become a spotty and decrepit line of hangers-on. Every year their remains are cut down and removed, and native paper birches planted between the stumps so that in time a new and more permanent allée will take the old one's place.

A lilac hedge bordering the entrance allée of Lombardy poplars was installed to frame a sloping vegetable garden that runs down to a garden shed with breezeway and weathervane, and on to a small greenhouse. The eastern view is dominated by the St. Lawrence, whose southern shore, some fourteen miles away, forms the horizon, and where indistinct villages glint in the setting sun.

One's first hesitant efforts to create a garden are often obliterated as one learns more about garden design or about the shortcomings of a site, or if one takes to heart the counsel of those favored with architectural wisdom. This has been my experience. At La

Malbaie, aggressive winds sweeping down from the Laurentians (we have called the place "Les Quatre Vents") dictated the construction of tall wooden windscreens. An architect, in the process of adding a guest wing to the house, installed a terrace with reflection pool where the garden had been and decreed a *"tapis vert"*—a long, narrow carpet of lawn running from the terrace to the edge of the stream gully. The *tapis vert* was flanked by a sunken blue garden and a raised white garden inspired by Vita Sackville-West's writings, centered on an oval lily pool. A double hedge of hawthorn and barberry in due course replaced the windscreens on both sides of the *tapis vert*, and the western view now flowed gracefully from the house to the mountains, unfettered by any horticultural distractions, the shallow reflection pool enhancing the spectacular sunsets of that northern clime.

It wasn't until some twelve years after I had inherited the house and garden in La Malbaie, when I had been increasingly exposed to the gardens of Britain and the myriad of landscaping devices and plant relationships they display, that the grounds' potential as a horticultural tour de force became apparent. It soon became clear to me that a number of gardens could be added to the basic framework, gardens that would make the whole more interesting, and result in a more diverse horticultural experience. There was space in which to expand, an unlimited supply of water from the stream, and a variety of different habitats for new plants. Over a period of ten years, I have filled the space and habitats one step at a time, without any particular forethought, but each step leading to the next. The gardens developed during this ten-year period supplement the good original landscape setting. Looking across the reflection pool and *tapis vert*, between the white and rose gardens and the frame of the hawthorn and barberry hedges, toward the mountains, one is not conscious of much change from the 1930s. It is only when one walks down the terrace steps towards the gardens that one realizes there are cross axes that lure one away from the *tapis vert*.

A Tour of the Garden

The new developments in the garden are best explored in tour sequence. An entrance in the hawthorn hedge, to the right, or north, of the *tapis vert*, leads into a narrow perennial allée flanked by a matching hawthorn hedge that finally is getting tall enough to give the desired tunnel effect. The allée, known as Goose Allée because of frequent visitations by the denizens of the lake at its foot, runs parallel to the *tapis vert* and is about one hundred feet long. At its upper end is a seat from which the visitor can enjoy the many tall and spiky perennials planted to enhance the tunnel effect. The "tunnel" directs the eye to a conveniently centered paper birch, by the water's edge, which ends the vista. The visitor is still not conscious that a lake is there.

The Goose Allée beds are terminated by clumps of *Daphne mezereum* underplanted with *Primula abchasica*, *P. vulgaris* ssp. *sibthorpii*, and *Scilla sibirica*, a felicitous combination of purple, mauve, and blue to start off the season. They are followed closely by *Doronicum* interplanted with *Brunnera* and, ultimately, a succession of *Aconitum*, *Cimicifuga*, *Delphinium*, *Ligularia*, *Rudbeckia maxima*, and *Thalictrum* providing the tall accents amid *Astrantia*, *Centaurea*, *Penstemon*, *Paeonia*, and *Trollius* in variety, among others.

A high *Thuja* tunnel leads off to the right and draws one across the Goose Allée, into a dark-green channel to an alcove adorned with a statue of one of the Four Seasons. The statue looks west through a rondel of *Thuja*, over a millstone converted to a sundial, then down to the lake and across to a somewhat battered bust of Antonia, the half-sister of Augustus Caesar, arising from a clump of *Clematis recta* and other perennials on the far shore. In the background, at the edge of the fields, a Lombardy poplar (a kind of living obelisk), has been planted as an exclamation point. The *Thuja* rondel is set within a *Thuja*-and-hawthorn square, with *Betula papyrifera* and *Acer ginnala* planted in the spaces between the two. At this first glimpse of the lake, one's curiosity is aroused.

Turning away from the vista through the rondel and continuing along the *Thuja* tunnel, the visitor suddenly emerges and finds himself crossing the middle of a string of six rectangular lily pools, with the water cascading and stepping down the gentle slope to the lake. The pools are flanked by *Thuja* planted in a quincunx pattern and by occasional matching clumps of three decorative rhubarbs. Looking to the right, the visitor looks up the watercourse to a dolphin at its head, the source of the water.

Crossing over the watercourse, one emerges into a longer, broader vista, again flanked by *Thuja* in a quincunx pattern whose size increases as one descends the slope. The vista slopes from the garage court down through a rhubarb allée to the north end of the lake. A Chinese bridge (made of plywood) that crosses the stream entering the lake in the distance is the focus this time, and draws one to the lake's edge, which is packed with naturalized perennials situated so as not to obscure any vistas. As one skirts the shore, the ducks and geese keeping a wary distance, there are agreeable glimpses through branches and flowers of the bust of Antonia.

The visitor now has two options. The energetic visitor will bear right and walk through a ten-acre stream garden planted to native trees and hardy shrubs.

Since the stream garden is planted with young trees, and it requires some imagination to visualize what it will be like in the year 2000, most visitors are spared the hike and happily cross the stream over the Chinese bridge and meander around the lake, where they catch a good view back over the lake and up the *tapis vert* towards the house.

The visitor then crosses the top of a high dam that separates the lake from the deep woodland ravine into which the stream falls. The banks of the dam have been planted with the white-flowered form of fireweed, *Epilobium angustifolium* forma *albiflorum*. By avoiding the *tapis vert* after crossing the dam and bearing right, along the edge of the woods, the visitor enters a new world.

The garden setting not only had fine views of the mountain and the river, but also had a handsome grove of young spruce when the site was first developed. My father could remember jumping over them as a boy around the turn of the century. Thirty years later, they were indeed a mossy fairyland.

One of the natural tragedies of our part of French Canada has been the destruction, by the spruce budworm, of the spruce and balsam fir forests that constitute 90 percent of the conifer forest. It has been a nightmare to watch beloved, dark-green hills turn, first brown, then a ghostly gray. It has taken fifteen years to do the killing, and millions of acres have lost these two species. Our place was no exception, and since our spruce had been allowed to grow to climax-forest maturity, the loss is all the worse, for there is nothing but brambles and alder scrub left to cover the *Cornus canadensis, Linnaea borealis, Pyrola,* and other delights. Happily, regeneration has started with a vengeance, and the budworm cycle is terminating, but it will be twenty-five years before the countryside regains its former character.

The spruce budworm wreaked its havoc on the grove of spruce near the garden. Slowly but surely the trees died. As they were knocked down by the wind and the light was let in, thickets of wild raspberries and elderberries ensued, and the grove became impenetrable.

The Shade Beds

It was at this point that three large shade-garden beds along the edge of the woodland were made out of what had been a mixture of weeds and scruffy lawn. The beds, which have been replanted and rearranged several times over, now contain a profusion of shade-loving plants that are at their best in early August, when the perennial gardens are "taking a breather" before the autumn show begins. Astilbes have been used to a great extent, large and small, and early and late bloomers. In one of the beds they have been intermixed with three species of *Aruncus*, four species of *Cimicifuga*, and the native red and white baneberries (*Actaea rubra* and *A. pachypoda*, respectively). In addition, lilies have been used liberally. The bed is divided roughly in half, and when everything works as it should one half is filled with white and pale-pink astilbes among which *Actaea rubra* and red lilies are thrusting their stalks, while the other half is the reverse, *Astilbe* 'Fanal' forming a background for *Actaea pachypoda, Campanula persicifolia* 'Alba', and a white lily. In June and July the bed is a mass of green foliage and little else, but it is worth forgoing the succession of bloom and waiting for the moment of glory.

A second bed consists of softer colors: the mauve and rose–pink astilbes interspersed with a pale-yellow lily, the buff tints of *Lilium marhan*, rose–pink *Lilium martagon*, the white form of *Meconopsis betonicifolia*, and the occasional blue spikes of *Campanula persicifolia*. This bed has been changed again and again, principally to take out lilies that, despite representations to the contrary, turned out to be orange, a color I have a difficult time with in the garden. The interplanting of the astilbes has also involved considerable thought, so that the succession and combination of color works to advantage.

The third bed has undergone the most changes of all. In 1984, it was a successful combination of *Lilium martagon* var. *album* and *Meconopsis betonicifolia* interspersed with the yellow form of *Primula alpicola*. But then two specimens of *Acer spicatum* that had provided adequate shade after the loss of an ancient spruce suddenly and inexplicably died, and the sunlight streamed in. In 1985, this bed was converted into a grass garden with varieties of *Miscanthus, Molina, Panicum, Pennisetum*, and other grasses, interspersed with mauve delphiniums. The *Primula alpicola* is still there, along with *Trollius* 'Alabaster', *Astrantia carniolica* var. *rubra, Allium christophii, Primula florindae*, and *Primula sikkimensis*. The meconopsis appear to be grateful that they were moved deeper into the woodland.

The Woodland Garden

The shade beds lead toward a grassy clearing at the end of the main perennial allée. The far side of the clearing is one of the entrances to the woodland garden and is the spot where the first experimental species of *Primula* and *Soldanella* were tried, with such success that moderation was soon thrown to the winds. For some reason, the spruce in this corner have withstood the ravages of the budworm. The earth consists of rich forest duff, rich enough to stick one's arm in to the elbow. The experimental plantings grew so rapidly that they could be divided twice, and sometimes three times, in the summer. In the spring the soldanellas bloomed profusely, something that doesn't happen at points south.

Clearly, this wretched and impenetrable woodland held promise, and over a six-year period the dead trees were felled and the brambles and other trash cleaned out. It turned out that there was an underplanting of young *Betula papyrifera, Amelanchier canadensis, Sorbus*, and *Acer spicatum*. These were thinned out and transplanted so as to spread their valuable shade throughout the rest of the copse. To provide the essential moisture, a two-inch plastic pipe was laid from the stream to the edge of the woodland, with the result that there now are four artificial streams that moisten the woodland floor, and a series of twenty-five overhead sprinklers that are operated for an hour or two each evening.

Not surprisingly, primulas love the habitat. We have been able over time to increase the number of species and the size of the plantings to where the little streams are now planted to great quantities of a given species and grouped by color variations where appropriate. For example, one stream is flanked with *Primula sonchifolia* and *Primula rosea*, mixed. Well over one hundred species are grown, including a number not often seen in eastern North America. *Primula vialii* flourishes, as does *Primula nutans* (now called *Primula flaccida*). *Primula nutans* is truly perennial and has the most captivating scent. *Primula reidii* var. *williamsii*, and *Primula reinii* from Japan, grow well along with *Primula reptans*, the smallest of the lot, which behaves like a ground cover, its large purple blossoms resting on its tiny, prostrate leaves. *Primula sapphirina* and *Primula primulina* also thrive, as do the petiolarids (with the exception of *Primula aureata*, which has yet to be wintered over successfully). Of course, the easy Auriculata, Candelabra, Efarinose, and Sikkimensis sections flourish, so much so that we have just barely been able to find places for the seedlings by diligently clearing new areas each summer. This work has proven exciting because of the nearby ravine, which is now cleared and being planted, and which affords an especially protected habitat—one reason the petiolarids and other plants collected in the Himalayas survive. The steep ravine slopes and deep snow cover are not unlike their habitats at home.

What is good for *Primula* is good for *Gentiana, Cardamine, Glaucidium, Rodgersia*, and others of their ilk.

Planting the Ravine

The stream and ravine curve in an arc of about seventy degrees. While I was visiting the beautiful Himalayan Glen at Wakehurst Place, its director, Tony Schilling, remarked that he hoped someday to install a Nepalese bridge across the top of the glen so that visitors could look down at the rhododendrons and other Himalayan species. It wasn't long before that excellent idea manifested itself over the ravine at La Malbaie in the form of two rope bridges copied from a sketch in Roy Lancaster's *Plant Hunting in Nepal*. The bridges are suspended at about sixty feet over the streambed and are just over one hundred feet long.

The ravine has been planted mostly with large-leaved species that will provide easily noticeable textural appeal for the nervous glances cast down upon them. The stream bed has been lined with *Petasites japonicus* var. *gigantea*, since there is room for it to romp and since it seems unlikely that it will climb up the steep banks.

Large colonies of five different species of *Rodgersia* have been laid out on the lower slopes and ravine floor, and *Bergenia cordifolia* sweeps down diagonally from top to bottom. The cirque formed by the arc has been planted to *Rhododendron yakusimanum* exclusively. When the small plants mature, it should be a splendid sight if there is not too much shade. A *Gunnera manicata* has survived its first (and rather bad) winter under extensive wraps, and it promises to fill a hollow in the ravine floor between the two bridges with its dramatic foliage.

Not that everything is perfect, of course. The hillside of *Primula pulverulenta* 'Bartley Strain' seedlings, planted so carefully last summer on a very steep slope, succumbed to the lack of snow cover, and to the ice and subsequent erosion in that unfortunate, windswept spot. But the hillside of *Meconopsis betonicifolia* intermingled with *Pri-*

mula alpicola var. *luna* × var. *alba* (which we have dubbed "Ivory Tower," for want of a better name) is in fine shape, as are the plantings of *Heracleum* on a steep and sunny spot. (We grow some ten species of *Meconopsis* in one part or another of the woodland.)

The next step will be to embellish these ravine slopes with bulbs. One slope is yearning for a mass of *Erythronium revolutum* intermingled with *Anemone blanda* 'Atrocaerulea' to sweep over its brow. The other slope would prefer *Corydalis ambigua* (or perhaps *Corydalis cashmeriana* or *Corydalis solida* var. *transylvanica*). Woodland gardening is heady stuff and, in this easy habitat, as good a way as any to spend the time.

A plantsman's inspection of the woodland garden—or *sous-bois*, as it is called locally—can take longer than is necessary at this juncture, but one of the paths leads out of the woodland, past a gazebo where one of the rope bridges terminates, and to where all orange plants of whatever genus (*Lilium, Primula, Trollius, Ligularia*, and others) have been exiled. They bloom harmoniously, without competition, against the green background. (A similar corner is filled with everything magenta.) The path joins a carriage drive that skirts a snake fence with good views of the bay and the river until it comes to the vegetable garden.

The Terraced Vegetable Garden

In its original state, the vegetable garden consisted of two long beds bracketing the path from the house down to the weathervane. The beds sloped both downwards and sideways and were not particularly satisfactory. The spruce trees killed by the spruce budworms came in very useful at this juncture, since one can salvage the value of the timber and clear the land of what promises to become an impenetrable barrier of fallen trees if one cuts within three years of the trees' death. Thus, we have had access to a great many spruce logs and have elected to use some of them to convert the vegetable garden into a series of terraced beds, building one bed a year. After six years, the project is finished, and the vegetable garden, now mixed with annuals and perennials for cutting, has a new lease on life.

Here again, there was no detailed plan when we started. The configuration of the beds was dictated by the degree to which the land fell away on a given slope. As a consequence, no two beds are the same, and each bed's shape conforms to the underlying contours. Some of the terraces within the beds are small and some quite large, but the whole provides an ample area in which to grow just about everything that could be grown. In time, as we figure out how best to use and combine the vegetables, annuals, and perennials within it, this garden should yield a lot of horticultural pleasure for all concerned. Terracing is probably the only logical solution to the problems of gardening on a slope.

There is nowhere left to walk but back towards the house through the lilac hedge enclosing the vegetable garden. There is a small meadow garden here, crisscrossed and formed into a series of more or less geometrically shaped panels by a series of paths. Every autumn a hefty contingent of bulbs is planted within it, and every summer new perennials and biennials are added to it in hopes they will take hold and establish colonies. It is a long but worthwhile process. A mosaic of *Crocus chrysanthus* in sweeps of blue, cream, and white appears in early May and expands as the years go by. They are followed by daffodils, which in turn are underplanted with *Scilla, Muscari, Puschkinia*, and *Chionodoxa*, each panel with its own combination of colors. There is a moment when *pissenlits* (dandelions) seem to be the only plant in evidence, but lupines soon assert themselves and put on a grand show in June and July, along with Oriental poppies, *Achillea ptar-*

mica, Filipendula, Campanula, and *Rudbeckia.* The trick is to extend the flowering season until the meadow is cut in early September.

Return of the Snow Geese

Perhaps the happiest time of the garden cycle in La Malbaie is early October—the horticultural evensong, when the season is over and our work done. The days are brisk, the nights cold, and the colors of the foliage exhilarating. The garden has been put to bed, the bulbs planted, and notes taken on what to move the next spring to improve a given planting. It is a time to cut trails, to build bridges, to make lakes, as well as a time to sketch plans and ideas for the future.

One crystal-clear October morning in 1984, I had time to wander at length along the various trails and to explore rarely visited byways that had been cleared. Along one byway, down a gently sloping, moist gully, the forest had escaped any damage, and there were still many fine ancient specimens of red and white pine. Partridge, woodcock, and hare flushed from along the trail, the mosses and mushrooms glistened, and the whorls of *Cornus canadensis* were deep purple. As the trail came to a cul-de-sac and I was beginning to explore how it could be blazed on, the unmistakable sound of the snow geese calling in flight broke the stillness. I hurriedly struggled out of the thicket and back up the trail to a point where I could look up at the sky. There was only one opening, a small one, and it was framed by the autumn colors of the maples, *Amelanchier*, and paper birch. Disappointed that I couldn't see the geese through that small, baroque window of blue sky, I was nonetheless struck by its beauty, a perfection worthy of Tiepolo, an intensity and combination of colors, backlighted by the sun, that were breathtaking. I gazed at it for a while and was about to stop when five snow geese, in formation and flying so low I could see the black tips of their wings, bisected the blue sky, framed for an instant in that incomparable setting.

Later that afternoon the weather suddenly deteriorated and became threatening. I had been planting the last of the bulbs in the woodland garden when it began to snow quite heavily. In a matter of minutes snow covered the ground, and I could imagine what it was like to be a petiolarid primula on the flanks of a Himal. The storm was sufficiently intense to cut visibility way down. All I could see were swirling snowflakes. Again I heard snow geese, only this time there were thousands of them, and I rushed to the edge of the woodland to try and see them. The snow was so thick by this time that a tree twenty feet away was barely visible and I despaired of catching even a glimpse of them when, suddenly, from all sides, hundreds of geese descended out of the clouds—on the front lawn, in the woodland garden, on the *tapis vert*, and in the fields beyond, which were just becoming visible again. I wondered if this was what heaven was like. It ended as quickly as it had begun. The snow geese, appropriately wrapped in the swirling cloud of snow, and over their apparent disorientation, lifted off the ground (had they ever touched it?) and disappeared.

What did it mean, I wondered. Did it mean it was time to stop gardening for that season, to reflect upon the mysteries of Nature and gather strength for the coming spring, when the snow geese would be heading north, and the gardening cycle would begin again? Was it a message confirming that we were fortunate in our earthly paradise, that we could do worse than to keep gardening in that northern woodland until our day was done?

Francis H. Cabot, of Cold Spring, New York, and La Malbaie, Québec, describes himself as a horticultural enthusiast. He is treasurer of the American Rock Garden Society and past chairman of the board of managers of the New York Botanical Garden.

Plant Hardiness-Zone Maps

Donald Wyman
Harrison L. Flint

Existing hardiness-zone maps are valuable, but using them requires knowing how they differ one from the other, and how "hardiness" has been defined

Plant hardiness-zone maps have been a valuable aid to those interested in predicting the adaptability of plants to specific climatic areas. Most are isotherm maps of geographical regions, based upon average annual minimum temperatures experienced at certain weather stations over some period of years. Many hardiness-zone maps are available—some cover small areas such as individual states, while others encompass entire countries. Unfortunately, many do not agree in their numbering schemes—so zone numbers assigned to individual plant species cannot be used in referring to all of the existing maps. In most cases they can be related only to the map used in assigning them. The two most widely used in this country are the Arnold Arboretum hardiness map and the "Plant Hardiness Zone Map" prepared by the Agricultural Research Service, United States Department of Agriculture (USDA).

Arnold Arboretum Hardiness Maps

The original map prepared at the Arnold Arboretum was published in the first edition (1927) of *Manual of Cultivated Trees and Shrubs*, by Alfred Rehder. In this map, the United States and southern Canada (except for southern Florida) were divided into eight zones characterized by 5-Fahrenheit-degree differences in lowest monthly mean temperature.

A few years later, the prototype of the present Arnold Arboretum hardiness map was prepared by Donald Wyman. It included the entire United States and was first published in his book *Hedges, Screens and Windbreaks*, in 1938. This map was based on average annual minimum temperatures for the years 1895 to 1935, as published in the *Atlas of American Agriculture*, USDA, in 1936. A modification appeared in the second edition of Rehder's *Manual of Cultivated Trees and Shrubs*, in 1940. In that book, the southernmost part of the United States was not included and much of Canada was added, in keeping with the manual's scope.

The Arnold Arboretum Hardiness Zone Map in use since 1949 includes the entire United States (except for Alaska and Hawaii) and southern Canada. This was first published in Wyman's *Shrubs and Vines for American Gardens*, and republished in his books *Trees for American Gardens* (1951 and 1965), *The Arnold Arboretum Garden Book* (1954), *Ground Cover Plants* (1956), and *The Saturday Morning Gardener* (1962).

The Arnold Arboretum map was revised in 1967 and again in 1971. The 1967 version was published in *Arnoldia*, while the 1971 version, which is the one published on the inside front cover of this issue of *Arnoldia*, appeared in *Wyman's Gardening Encyclopedia*.

Reprinted, with slight modifications, from *Arnoldia*, Vol. 27, No. 6, pages 53–56 (June 30, 1967).

The 1967 map differed from the previous version only in that hardiness-zone lines were redrawn to conform to more recent weather data. The zone-numbering system was unchanged—so zone numbers applied to specific plants in Rehder's manual and other publications by the Arnold Arboretum staff could be used with the newer map just as well as with its predecessor.

USDA Plant Hardiness-Zone Map

This map (Figure 1) was issued in 1960 as Miscellaneous Publication No. 814 of the Agricultural Research Service, USDA. It contains uniform zones of 10 Fahrenheit degrees, and sub-zones of 5 Fahrenheit degrees. Since the Arnold Arboretum map uses zones of different ranges (5, 10, or 15 Fahrenheit degrees), discrepancies between the two are inevitable. Unfortunately for the casual user, these inconsistencies are small enough to be overlooked, and in several instances, writers have erroneously applied the hardiness-zone designations of Rehder to the USDA map. The table shows the relationship between the two numbering systems.

Local Hardiness-Zone Maps

More-detailed plant-hardiness-zone maps have been prepared for certain states and localities. The total area covered by such maps is still rather small. Fortunately some detailed maps use the same zone-numbering system as the larger, more general maps. A good example is a hardiness-zone map of the state of Vermont (Hopp and Lautzenheiser, 1966). This map uses the same zone-numbering system as the USDA map, but is based upon a larger number of weather stations in Ver-

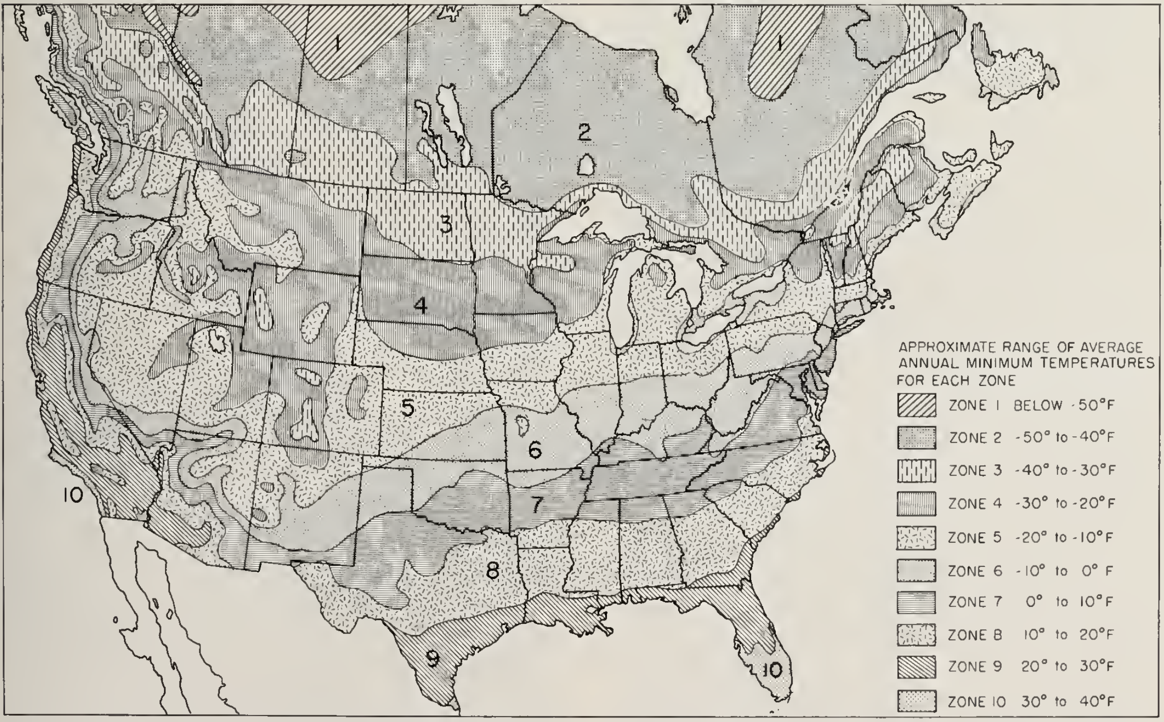


Figure 1. The U.S. Department of Agriculture's plant hardiness zones in the conterminous United States and southern Canada.

mont, so zone lines have been drawn in more detail than in the larger map. As more areas are mapped in greater detail in this way, hardiness-zone maps will become increasingly useful.

Canadian Plant Hardiness Map

The Canadian Plant Hardiness Map, released in 1967 by the Canada Department of Agriculture, covers all but the far-northern parts of Canada. This map represented a new approach in that it was an attempt to describe hardiness zones in terms of the whole complex of environmental factors that contribute to severity of climate, rather than in terms of a single factor such as average annual minimum temperature. To as great an extent as possible, actual observations of plant adaptability played a part in describing hardiness zones.

Direct comparisons between this map and those prepared in the United States are not valid, because of the different criteria used in describing hardiness zones.

The Future

It appears that the business of preparing hardiness-zone maps and assigning plants to their proper zones is still in the experimental stage. Hopefully, we may eventually see wide adoption of a single hardiness-zone map for the United States, for North America, or even for the northern hemisphere. If this is someday accomplished, the problem of assigning realistic zone numbers to specific plants will still remain. The ability to match plants with zones over wide regions will be the ultimate test of any map, and many more careful observations will have to be made before this can be done with most of our present trees and shrubs. Meanwhile, the existing maps will continue to be useful. But to use them most effectively we must recognize their differences and use published zone references only with the right map.

Relationship Between the Arnold Arboretum and USDA Hardiness-Zone Numbering Systems

Arnold Arboretum Hardiness Zone	*Range of Average Annual Minimum Temperature, F*	*United States Department of Agriculture Hardiness Zone*
1	*Below −50*	*1*
2	*−50 to −45*	*2a*
	−45 to −40	*2b*
	−40 to −35	*3a*
3	*−35 to −30*	*3b*
	−30 to −25	*4a*
	−25 to −20	*4b*
4	*−20 to −15*	*5a*
	−15 to −10	*5b*
5	*−10 to −5*	*6a*
6	*−5 to 0*	*6b*
	0 to 5	*7a*
7	*5 to 10*	*7b*
8	*10 to 15*	*8a*
	15 to 20	*8b*
9	*20 to 25*	*9a*
	25 to 30	*9b*
10	*30 to 35*	*10a*
	35 to 40	*10b*

Reference

Hopp, R.J., and R.E. Lautzenheiser, 1966. *Extreme Winter Temperatures in Vermont.* University of Vermont Agricultural Experiment Station Bulletin 648, 19 pages.

Donald Wyman was horticulturist for the Arnold Arboretum from 1936 to 1970, during which period he was editor of *Arnoldia*. His *Gardening Encyclopedia* is a standard reference for gardeners and horticulturists. Harrison L. Flint, a former staff member of the Arnold Arboretum, is professor of horticulture at Purdue University. Among his best-known publications is *Landscape Plants for Eastern North America* (Wiley, 1983).

BOTANY: THE STATE OF THE ART

What Determines a Plant's Cold Hardiness?

John W. Einset

Cold-tolerance depends upon a plant's ability to keep water from leaving its cells and freezing, which severely dehydrates the cells

Banana plantations along Cape Cod, orange groves in the Berkshire Mountains, tropical landscaping in New England! Unlikely as these images seem, they are not entirely out of the realm of possibility, especially if more can be learned about the basic mechanisms that govern the tolerance of plants to cold. In fact, goals less spectacular than these, yet still highly significant, are achievable in the near future because both our understanding of plant physiology and our ability to manipulate plant cold hardiness have improved.

Without question, resistance to low temperatures is a major factor determining the geographic distribution of plant species. So-called *chilling-sensitive* plants, such as the tropical banana and the semitropical avocado, can be severely injured or even killed by long-term exposure to temperatures (50 degrees Fahrenheit, for example) that are well above freezing. By contrast, *chilling-resistant* plants, such as garden peas and potatoes, survive brief periods of frost but are killed when freezing conditions continue for more than about four hours. *Cold-hardy* plants, on the other hand, tolerate extended periods of freezing, and laboratory tests indicate that cold hardiness in some of these plants permits them to survive at temperatures as low as minus 75 degrees Fahrenheit.

What causes such wide variations in the sensitivity of plants to cold? As a consequence of natural selection, plants native to a particular hardiness zone are adapted to the temperature extremes that occur in their environment. Remove them from that environment, and they may or may not survive. For example, banana plants kept at low, but nonfreezing, temperatures suffer an imbalance in their metabolism that kills their cells and causes brown necrotic streaks to appear on fruits. Or, hardier plants might be killed by frost that occurs during their normal period of vegetative growth. Several cultivars of rhododendrons and azaleas that are grown successfully in Georgia and the Carolinas, for instance, are killed by late frosts when they are transplanted to New England only because their tender vegetative buds initiate growth too early in spring. Other plants fail to survive because late-summer frosts kill vegetative shoots before they become acclimated to cold temperatures.

During any given year, a species of tree or shrub adapted to the north-temperate environment alternates between periods of cold hardiness and cold sensitivity. The term *acclimation* (hardening) refers to the transition from a sensitive to a hardy condition, while *deacclimation* (dehardening) designates the hardy-to-sensitive transition. Obviously, the seasonal timing of acclimation and deacclimation is of critical importance in determining a plant's cold hardiness. The magnitude and duration of the acclimated state are also crucial. In fact, the Arnold Arboretum's hardiness zones classify woody-plant species according to the magnitude of the cold tolerance they exhibit in their acclimated states. Zone 6 plants, for instance, can withstand minimum temperatures of plus 5 degrees Fahrenheit to minus 5 degrees Fahrenheit, while plants of zones 5, 4, 3, 2, and 1 exhibit progressively greater cold hardiness. Obviously, plants in all of these categories can tolerate some below-freezing weather; it is the magnitude of their tolerance that differentiates them.

When a plant, regardless of its hardiness classification, is injured by a killing frost, several harmful processes are involved. One of the earliest and most critical processes is the formation of ice crystals in the spaces between their cells. Freezing of the water in the intercellular spaces causes water in the adjacent living cells to move out of the cells into the intercellular spaces, where it, too, freezes. The amount of ice in the intercellular spaces increases rapidly as additional water moves out of the cells. Left unchecked, the loss of water from cells causes severe dehydration. In fact, the most widely held explanation of frost damage in plants is that death is caused directly by the advanced state of cellular dehydration that results when ice forms in tissues. According to this explanation when the concentation of water in cells falls below a critical "threshold" value, protein molecules in the cells' protoplasm begin to cross-link with each other, forming a stable but nonfunctional matrix. In this permanently altered state of protoplasm, metabolism slows to a standstill and, since the cells die, the entire plant dies.

Apparently, species of plants that survive temperatures lethal to other species do so by preventing the dehydration caused by ice formation. One way in which they accomplish this involves "supercooling"—the absence of ice formation even during periods of freezing temperatures. Another way is for ice to form in the intercellular spaces but for the loss of water from cells to be reduced. Often, this means of frost prevention involves osmotic alterations in the protoplasm of hardy plants. Halophytes (salt-tolerant plants), for example, usually are hardier than their non-salt-tolerant relatives because the higher osmotic concentration of their protoplasm effectively prevents water from leaving cells and contributing to extracellular ice crystals. Some other hardy plants generate high internal contents of organic solutes (dissolved compounds) during acclimation. Finally, certain plants are cold tolerant simply because they can recover from even the extreme dehydration that accompanies ice formation. Examples of such species are paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), and several willows.

In view of all these considerations, what practically can be done to prevent freezing injury in plants? An obvious strategy is to ensure that plants are well-watered before periods of potential frost. By keeping their tissues turgid, or swollen, one might be able to prevent the extreme cellular dehydration that usually kills frosted plants. A related treatment is to spray tender plants with water whenever temperatures are below freezing. The rationale of this procedure is twofold. First, it maximizes the water content of living tissues and, second, the heat (known to physicists as the heat of fusion) given off when water on the surface of a plant freezes, counteracts the effect of freezing temperatures on water within the plant. In Massachusetts, for example, cranberry growers routinely use water sprinklers in their bogs during late-spring frosts to take advantage of the heat of fusion released when water freezes on the surface of cranberry plants. The heat released by 100 gallons of water when it freezes is approximately equivalent to the amount of heat produced by burning one gallon of fuel oil. Obviously, the sprinkler technology is an important frost-protection measure. Breeding programs to introduce hardiness genes into less hardy plants may also become extremely important in the next few years.

Other ways of preventing frost injury in plants are still in the experimental stages and therefore are not yet of practical value. Some, in fact, are quite controversial. Researchers at the University of California, for example, are attempting to utilize genetically engineered strains of bacteria as frost-protection agents. They reason that some bacterial species called "ice-nucleating bacteria," normally associated with plants, tend to sensitize plants to freezing injury, since individual bacteria act as "nucleation centers" for the formation of ice crystals. Other bacterial species, by contrast, are nonnucleating. Displace ice-nucleating bacteria on a plant with nonnucleating ones, it is argued, and the plant should be less prone to frost injury. Unfortunately, it is still too early to judge whether theory and practice are compatible

The paper birch (Betula papyrifera), *in the Arnold Arboretum (left), and the trembling aspen* (Populus tremuloides), *in the San Francisco Mountains, Arizona, are cold tolerant simply because they can recover from the extreme dehydration due to the formation of ice in their intercellular spaces. Many other species are cold tolerant because they prevent dehydration of their cells in the first place. Photograph of* Populus tremuloides *by Susan D. McKelvey. Both photographs from the Archives of the Arnold Arboretum.*

in this case. Not only that, but several experts question the wisdom of introducing potentially harmful bacteria into the environment. They identify several important questions. Will the engineered bacteria cause undesirable plants, such as weeds, to become frost tolerant, too? Or, since the ice-nucleating bacteria normally present on plants may have beneficial but unrecognized effects on their host plants, might not their beneficial effects be abolished? Lastly, is it possible that nonnucleating bacteria could affect the weather, a prospect that could have profound consequences?

As is the case whenever basic science is used to solve practical problems, resolution of the public's concerns about nonnucleating bacteria as frost protectants will ultimately depend on the results of controlled experiments designed to identify possible adverse environmental effects of this practice. If none are found, then significant progress will have been made on one strategy for manipulating plant cold hardiness. As usual, improved scientific understanding of a phenomenon, such as cold hardiness, if it is properly applied, has the potential of improving horticultural technology.

John W. Einset, a staff member of the Arnold Arboretum, is associate professor of biology in Harvard University.

A Letter to Readers

Arnoldia has been published continuously by the Arnold Arboretum since 1911. Next year will mark the magazine's seventy-fifth anniversary. During *Arnoldia*'s seven and one-half decades of existence, its format, frequency of publication, subject matter, and even purpose have changed dramatically—from weekly or fortnightly newsletter published only during spring, summer, and fall, to monthly, then bimonthly, and finally quarterly magazine covering most aspects of horticulture and botany. During its early years the publication was called the *Bulletin of Popular Information*. The name was changed to *Arnoldia* in 1941.

In 1986, *Arnoldia*'s tradition of evolution will continue. Appropriate (but modest) changes will be made: minor adjustments in format, improvements in quality, increases in content, broadening of scope and diversity, etc.—all without rises in production costs. In fact, with respect to cost, the goal will continue to be economy in every possible way. This goal of cost-cutting will be pursued in part through the aid of much-appreciated volunteer help from Friends of the Arboretum, and others. At the same time, a serious campaign will be launched to raise outside funding for special issues, as well as for general operating costs.

Ten months ago, the Friends of the Arnold Arboretum, who receive *Arnoldia* as a membership benefit, were polled on their attitudes toward the Arboretum, membership benefits, and so on. From *Arnoldia*'s perspective, the response was especially gratifying. Rated at or very near the top as a membership benefit, *Arnoldia* was held to be an important benefit by a margin of seventeen to one.

A difficult and important challenge for *Arnoldia* in the coming year or two will be to expand its mix of subject matter without neglecting or abandoning any of the traditional subjects that have delighted readers over the years. To guide the staff members and volunteers who produce *Arnoldia* in that critical task, a questionnaire will be sent to all readers, Friends and subscribers alike, early in 1986, in the hopes that they will share valuable insights and opinions with those of us who produce the magazine.

The past twelve months have been a period of careful analysis and assessment of *Arnoldia*'s role vis-à-vis the University, the Arboretum, and the Friends. The verdict has been favorable in every respect. During the period of introspection, however, *Arnoldia* fell substantially behind in its publication schedule. The spring and summer issues have appeared only in the last month. With the present issue, *Arnoldia*'s normal publication schedule resumes. Winter issues will again appear in January, spring issues in April, summer issues in July, and fall issues in October.

During 1986, a variety of interesting articles and special issues will be published by *Arnoldia*—a special issue on the Arboretum's historic involvement in Chinese botany, as well as an issue on the vine, articles on camellias, enkianthus, plant collecting in China and North Africa, propagation of *Metasequoia*, and the multifarious activities of the Arboretum's staff members. In 1986 or 1987, we hope to have articles or special issues on the forests of the United States, Chinese food plants, plant conservation, and techniques for ameliorating the impacts of air pollutants on woody ornamentals and other cultivated plants. As always, we will be eager to consider manuscripts on horticultural or botanical subjects for publication.

We are grateful for the patience and enthusiastic support readers have accorded *Arnoldia* over the past twelve months and hope they will continue to express their support by responding to the questionnaire next year.

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Index to Volume 45

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