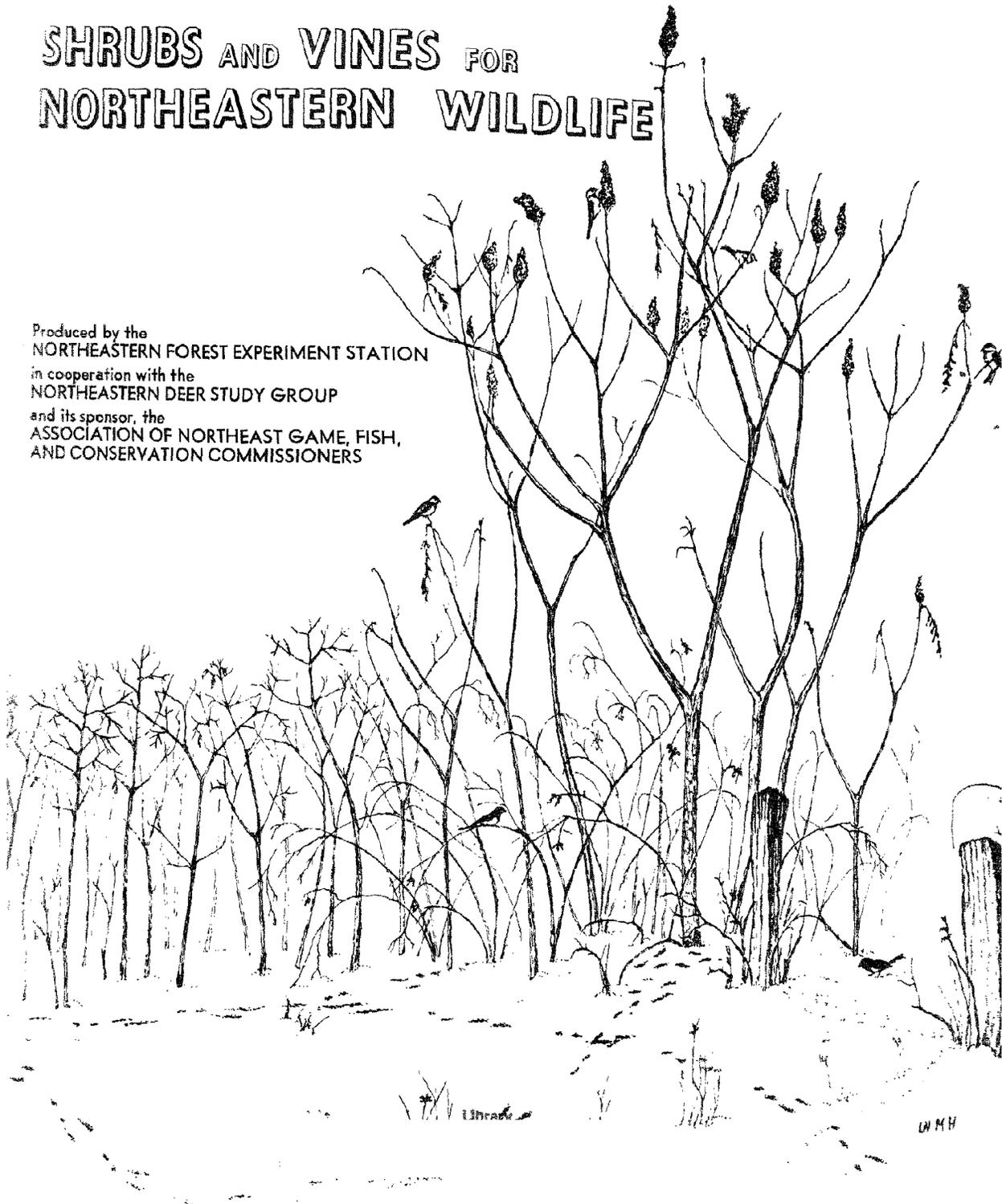


SHRUBS AND VINES FOR NORTHEASTERN WILDLIFE

Produced by the
NORTHEASTERN FOREST EXPERIMENT STATION
in cooperation with the
NORTHEASTERN DEER STUDY GROUP
and its sponsor, the
ASSOCIATION OF NORTHEAST GAME, FISH,
AND CONSERVATION COMMISSIONERS



ACKNOWLEDGMENTS

When the Northeastern Deer Study Group, sponsored by the Association of Northeast Game, Fish, and Conservation Commissioners, agreed to take on the job of producing this handbook, Chairman James S. Lindzey of the Pennsylvania Cooperative Wildlife Research Unit appointed Stephen A. Liscinsky of the Pennsylvania Game Commission and John D. Gill of the U.S. Forest Service to lead the project. They in turn called on Robert D. McDowell of the University of Connecticut, Earl F. Patric of the New York State University College of Forestry, and Ward M. Sharp of the USDI Bureau of Sport Fisheries and Wildlife for advice and review of plans.

Deer Study Group members in nearly all the northeastern states and provinces participated in selecting the species included in the report and in recruiting authors. At least 21 people functioned as key-men for individual areas or agencies. We cannot name all of them, but Joseph S. Larson of the University of Massachusetts and Stuart L. Free of the New York Department of Environmental Conservation were especially active in recruiting authors. When word of the handbook spread beyond the Northeast, we got additional help from Forest W. Stearns, then with the North Central Forest Experiment Station at Rhineland, Wisconsin. Stearns' interest confirms that this handbook should be useful in the Great Lakes area as well as in the Northeast.

The work of most of the authors who are employed by state conservation departments and of several other biologists who are not specifically named here was supported by Federal Aid in Wildlife Restoration Funds. Francis B. Schuler of the USDI Bureau of Sport Fisheries and Wildlife at Boston has consistently encouraged the kind of cooperation among agencies that this handbook reflects.

So many other people helped that we do not have space to name all of them. But we must particularly thank Earl L. Core, who helped and encouraged us throughout this project.

—JOHN D. GILL and WILLIAM M. HEALY

NORTHEASTERN FOREST EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
6816 MARKET STREET, UPPER DARBY, PA. 19082
WARREN T. DOOLITTLE, DIRECTOR

SHRUBS AND VINES FOR NORTHEASTERN WILDLIFE

**Compiled and revised by
JOHN D. GILL and WILLIAM M. HEALY**

JOHN D. GILL leads the Northeastern Forest Experiment Station's wildlife-habitat research project at the Forestry Sciences Laboratory, 180 Canfield Street, Morgantown, West Virginia 26505, in cooperation with West Virginia University. Gill is a member of the University's graduate faculty in the Division of Forestry. He joined the Forest Service in 1967 after service in the Maine Department of Inland Fisheries and Game (Orono, 1955 to 1967) and the West Virginia Conservation Commission (Elkins, 1950 to 1955). While attending Michigan State University (1947 to 1950) he worked part-time for the Michigan Game Division.

WILLIAM M. HEALY, associate research wildlife biologist, has worked with Gill since completing master's degree studies at the Pennsylvania State University in 1967. His research mostly concerns habitat requirements of wild turkeys. He also holds the rank of instructor in the West Virginia University Division of Forestry and is working toward a Ph.D. degree in animal behavior.

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A HANDBOOK ON SHRUBS AND VINES

By John D. Gill and William M. Healy

*USDA Forest Service
Northeastern Forest Experiment Station
Forestry Sciences Laboratory
Morgantown, West Virginia*

This handbook was prepared to provide practical information about managing the shrubs and woody vines of the Northeast that are important to wild birds and mammals for food and protective cover.

This work stemmed from forest-wildlife research needs expressed in a series of analyses begun within the Northeast Section of The Wildlife Society and later sponsored by the Association of Northeast Game, Fish, and Conservation Commissioners. A committee organized by federal-aid supervisors in the USDI Bureau of Sport Fisheries and Wildlife at Boston recommended preparation of a handbook to pull together available information that would be useful in the management of shrubs and vines for wildlife. The committee noted that, though several recently published handbooks provided information about commercially valuable tree species, no such handbook was available for the smaller woody plants.

Work on the handbook began in 1967 when the Northeastern Deer Study Group, sponsored by the Commissioners, agreed to take on the job.

As the first step in planning the handbook, we listed nearly all the shrubs and woody vines that had been reported to have some kind of value for wildlife. Then biologists

throughout the Northeast were asked to review the list and rate the plants to help us select the most important species to include.

The selected list includes plants in 36 genera and 100 species. Besides the native plants, we included three exotics that have become widely naturalized: a rose and two honeysuckles.

There may be some bias in the selection, because most of the wildlife biologists who participated in selecting the plants had been working almost exclusively with game species, and many were specialists on deer. However, we feel that this bias is not serious, because many groups of game animals and non-game animals have similar habitat requirements.

We made no attempt to illustrate the plants for purposes of identification. Illustrated field guides to woody plants are readily available, as are state and provincial flora publications.

The handbook contains 41 chapters by different authors. To avoid repetition, literature references have been consolidated into a single list at the back of the book. A glossary of terms is also appended.

The authors hope that this handbook will prove useful not only to wildlife managers, but also to anyone who owns or manages land or is interested in providing favorable habitat for wildlife.

ECOLOGY OF SHRUBS AND VINES

By Ward M. Sharp

*Bureau of Sport Fisheries and Wildlife
Warren, Pennsylvania*

The ecology of shrubs and woody vines concerns the interactions among shrubs and vines, other plants, animals, and the environment. As examples, interactions of shrubs with other plants and with fire have an impact on the welfare and development of shrubs in the landscape. Animals play a key role, exerting both beneficial and detrimental effects.

Shrubs cannot be defined exactly. Generally, they are low, erect, woody plants, usually under 25 feet in height, and usually have several stems. Any definition is arbitrary because of the great variation in height and form. The person who is not familiar with either trees or erect shrubs may encounter difficulty in distinguishing tree regeneration or small trees from shrubs.

GROWTH FORMS

Individual species fall into one, or in some cases more than one, of the following categories: (1) erect shrubs, either clonal, multi-stemmed, or single-stemmed; and (2) climbing or trailing shrubs or vines.

Clonal shrubs and vines form dense colonies from underground, horizontal rootstocks. Colonies may develop from a single seedling. Smooth sumac (*Rhus glabra*) grown from seed will start clonal development by the fifth year. Other plants of clonal habit, for example, are lowbush blueberries (*Vaccinium* spp.), gray-stemmed dogwood (*Cornus racemosa*),

blackberries (*Rubus* spp.), and the low serviceberries (*Amelanchier* spp.). In optimal sites American elder (*Sambucus canadensis*) may become clonal. Fire stimulates seed germination in all clonal species, and some species such as lowbush blueberries need to be burned on a rotation basis.

The multi-stemmed shrubs include those that produce numerous stems from a common root collar. Typical examples are the highbush blueberries, witherod (*Viburnum cassinoides*), and mountain laurel (*Kalmia latifolia*).

Single-stemmed shrubs include many of the tall species. Shrubs in this group grow from a single stem, or sometimes two or more stems may originate from near ground level. Flowering dogwood (*Cornus florida*), hawthorns (*Crataegus* spp.), and hophornbeam (*Ostrya virginiana*) belong in this category.

Climbing or trailing woody shrubs or vines are ecologically similar to erect shrubs, although in appearance the relationship may seem remote. The vine growth form may hold for all species of a genus such as grape (*Vitis*) or greenbrier (*Smilax*), but not for all species of genera such as honeysuckle (*Lonicera*) or bramble (*Rubus*).

The climbing vines often use erect shrubs or trees for support and access to sunlight. Woody vines, like wild grape, usually become established at the same time as new tree and shrub regeneration. Once established, they

grow along with their supporting plants. They seldom take hold in forest stands once the trees attain pole-timber size. Trailing vines such as dewberries (*Rubus* spp.) usually grow in open fields. They compete for sunlight with grasses and forbs by trailing over the herbaceous plants.

ENVIRONMENTAL FACTORS

The principal factors that interact on shrubs are (1) physical—sunlight, soils and moisture, temperature, and fire; and (2) biological—browsing, insects and disease, and seed dispersal by animals.

Sunlight

Among all the environmental factors, full sunlight is most important for nearly all species. When luxuriant shrubs are shaded by the dense canopy of invading trees, most species become suppressed and wane regardless of other factors such as moisture, temperature, and soil nutrients. When taller shrubs are shaded after they reach normal height, they may persist longer than the low-growing species. Those that persist are suppressed. Their vigor wanes and their fruiting potential declines.

There are exceptions to this, however. A few species grow well in partial or full shade. But the majority grow best and produce the most fruit in openings such as road edges, old fields, and clearcut forest stands.

From the importance of full sunlight in the life span of most shrub communities, one may reason that shrubs evolved in a grassland or a forb-grass environment. They transformed these sites into savannas that later were invaded by trees. Man and fire have played leading roles in perpetuating sunlight exposure in the shrub community.

Soils and Moisture

Soil and moisture are combined here because shrubs tolerate a wide range of soil and moisture conditions. Some shrubs occur in wet sites while others need dry upland sites. This requirement varies even among species of the same genus, such as blueberries. Lowbush blueberries require dry upland soils; native

highbush blueberries establish best in wet soils or soils that are waterlogged in spring.

Some shrubs prefer soils of limestone origin; others prefer acid soils of sandstone origin; and others are tolerant of a wide range of soil and moisture conditions. This trait also varies among species within a genus such as serviceberry, dogwood, and hawthorn. The shrubby roundleaf serviceberry (*A. sanguinea*) occurs in Pennsylvania on limestone soils, while downy serviceberry (*A. arborea*) is common throughout the state.

It is pointless to try to lay down hard and fast rules on the soil and moisture requirements of shrubs and vines in general. These needs are as variable as the needs among tree species.

Temperature

Temperature is most important during flowering and setting of the fruit crop. When temperatures drop below freezing during flowering, the entire fruit crop may be eliminated. In other respects, native shrubs in the region are adapted to temperature extremes in winter.

Fire

Fire has been a key factor in the shrub community for so long that many species evolved through periodic occurrence of fire. Consequently, many shrubs are fire-adapted. The known fire-adapted species are those that form clonal colonies from a horizontal root system. Many of the multi-stem groups benefit from the influence of periodic burning. Shrubs of the heath family such as blueberries, huckleberries, and mountain laurel are rejuvenated by periodic burning.

Fire serves four roles in shrub management. It is a pruning and sanitation agent for cleaning up dead or decadent stems; it tends to set back tree regeneration; it is conducive to breaking seed dormancy and stimulating germination; and it helps control disease and insects.

For fire to serve best, it must be used periodically and in a prescribed manner. Except for lowbush blueberries, the optimum intervals between burnings have not been resolved. Pre-

scriptions should give season, moisture conditions, and the method under which fire is used. Optimal benefits are usually derived from burning in early spring. Burning in droughty periods or after leaves have unfolded may be more detrimental than beneficial. The beneficial role of fire in shrub management is neither widely recognized nor practiced in wildlife management.

Browsing

The impact of browsing on shrub or vine species depends largely on their palatability to browsing animals, mainly deer, rabbits, rodents, and livestock. Most shrubs are vulnerable only at a particular stage in their life cycle, such as the seedling and early regeneration stages.

The tops of some clonal and multi-stem shrubs never grow beyond the reach of browsing mammals. Therefore these shrubs have developed growth qualities that resist browsing. Crowns of low hawthorns, for example, become hedged from browsing; and the thorny, hedged crowns prevent overbrowsing. Inhibiting substances which render some shrubs unpalatable are known. Mountain laurel is toxic to some hoofed animals, especially sheep; and elderberries are unpalatable to cattle.

The effects of browsing by deer may vary because of changes in factors other than the browsing itself. For example, Pennsylvania had a large deer herd in 1930 to 1960. In that period, a closed-canopy poletimber forest also developed. Such shrubs as mountain laurel and the scrub oaks—lightly browsed by deer and intolerant to shading—died beneath the closed canopy of trees. Therefore all factors of the shrub environment must be evaluated before damage is attributed exclusively to deer.

Cottontails and woodchucks prefer seeding shrubs under 24 inches in height. In my attempts to propagate American elder in wildlife areas, woodchucks and cottontails were as destructive as deer. Mice girdle shrubs at ground level; consequently, their damage may go undetected.

Insects and Diseases

The detrimental impact of insects and fungous diseases may be greater than that of browsing mammals. This impact may be local, it may go undetected, or it may be more prevalent among certain groups of shrubs than among others.

Insects are principally defoliators, but some attack the succulent shoot tips or the woody branches. Defoliators are periodic as a rule, but complete defoliation even for one season can trigger a decline in shrub vigor. I have observed that defoliation in a colony of gray dogwood was followed by failure to set fruit in the following years and by top dieback. Sucking insects such as lace bugs and aphids may destroy the leaf chlorophyll, leaving the foliage with a seared to brownish appearance by August. Aphid attacks on succulent shoot tips in seedling shrubs can weaken plants so that they succumb to winter-kill or drought.

The fungous diseases most frequently encountered among shrubs are those that attack the flowers, fruits, leaves, and stems. Those attacking the rootstocks are little known except by pathologists and may go undetected. Rust, leaf spot, and mildew are the diseases most frequently observed.

Many of the fungi may affect the flowers and fruits, thus reducing fruit quality and yield. Affected fruits either drop prematurely or those that persist are deformed or mummified (*Heald 1926*). Fruits of wild grapes are commonly mummified by fungous diseases. Rust diseases may be fatal. For example, hawthorn rust is often fatal where the alternate host, eastern redcedar (*Juniperus virginiana*), is common. Leaf spot diseases kill parts of the leaves, thus reducing photosynthetic activity. They also affect the flowers and fruits. The impact of disease on shrubs results in unthrifty or undernourished plants or total kill.

Prescribed or controlled burning in shrub communities will help control fungous diseases, such as leaf spot, and some defoliating insects. But rust control is realized only by removal of the alternate host. Fungicidal sprays are not considered economically feasible for native shrubs. Spraying insecticides for leaf defoliators is also impractical in managing shrubs in a unit of wildlife range.

Seed Dispersal by Animals

Shrubs and vines that produce berries or fleshy fruits depend on birds and mammals for seed dispersal. Seeds of these fruits are mostly small with hard seedcoats; and when eaten by most birds and some mammals, they are passed through the digestive tract either unharmed or treated so as to increase germinative capacity (*Krefting and Roe 1949*).

Birds are more efficient disseminators than mammals. In bird droppings, seeds are more widely dispersed, and fewer seeds are deposited at one site. Mammals such as raccoons and foxes deposit numerous seeds at a spot.

But birds and mammals may destroy those seeds that have a large endosperm, such as hazelnuts (*Corylus* spp.), scrub oak acorns (*Quercus ilicifolia*), or chokecherry (*Prunus virginiana*). Small rodents, in particular, consume the embryo along with the endosperm.

LAND USE

The era of native shrubs and vines probably reached its peak between 1900 and 1920 in the Middle Atlantic and Northeastern States. Up to that time, vast acreages had been converted to farm and pastureland. Livestock production equalled that of row crops. Lumbering operations had converted extensive areas to brushland. Use of fire in the landscape was a common and accepted practice. The period before 1920 was the agricultural era in the region.

Farm and pasture abandonment was characteristic of the decades after 1920. Beginning about 1933, fence rows between fields were being eliminated in a move toward clean farm-

ing. Land in farms and pastures in New York, for example, totalled 22,600,795 acres in 1910, but by 1950 farm abandonment had reduced this area by 40 percent to 13,672,937 acres (*Conklin 1954*). A similar or even greater abandonment of farm and pasture land since 1910 or earlier has occurred in most northeastern states. (*Frey et al. 1957*). The trend is continuing.

It has not been generally realized that in the agricultural era, conditions of rural living (including clearing and burning, extensive acres of pastureland, fence rows, and early lumbering operations) enabled native shrubs to flourish and increase in abundance. Now, with clean farming, use of herbicides, and conversion of abandoned farms to a closed-canopy forest, native shrubs have declined in sites where they were formerly abundant. These conditions point up the need for an aroused interest in the ecology and management of native shrubs and vines.

Beginning in the 1930s, shrubs from other parts of the world took precedence over native species. Much emphasis has been placed on exotic species for wildlife and soil-erosion plantings since that time. Consequently, native species received little study except by a few individuals who recognized the limitations and risks of exotics compared to native species. Even with the emphasis on planting millions of exotics in wildlife habitats, they have contributed little forage or fruits for wildlife. Having conducted studies in shrub ecology over the past two decades in Pennsylvania, I can only view the future with concern if interest in native shrubs continues to lag as in the past four decades.

ALDERS

SPECKLED ALDER, *Alnus rugosa* (Du Roi) Spreng. Also called Hoary or Tag Alder.

HAZEL ALDER, *Alnus Serrulata* (Ait.) Willd. Also called Common, Smooth, and Streambank Alder.

By William M. Healy and John D. Gill
Northeastern Forest Experiment Station
Morgantown, West Virginia

RANGE

The combined ranges of the two species include the entire region. Speckled alder occurs from Newfoundland to British Columbia and southward to Maryland, West Virginia, Ohio, northern Indiana, and Minnesota. Hazel alder grows as far north as Maine and ranges southward to Florida and Texas (*Gleason 1963b*).

HABITAT

Speckled alder is the more northern species. It is most common along the northern boundary of the United States (*Brickman 1950*) and is restricted to higher elevations at the southern edge of its range. In West Virginia, hazel alder grows mostly at elevations below 2,600 feet, while speckled alder is common in the mountains above 2,600 feet (*Strausbaugh and Core 1952-64*). Optimum growing conditions for the alders have not been described, but it is possible that climatic factors limit both species at the edges of their ranges.

Alders most commonly occupy poorly drained soils. Typically, they border streambanks and form thickets where surface drainage is slow and the ground-water level is near

the surface during part of the growing season. Saturated soil appears to be required for seed germination.

One study showed that saturation for intervals of 1 to 16 days stimulated growth of newly emerged hazel alder seedlings (*McDermott 1954*). In a study in northern Michigan, *Brickman (1950)* found speckled alder growing only on sites that had a saturated soil during the spring months, although some alder sites became dry during late summer. From this and other observations, he felt that speckled alder requires a saturated soil on which to germinate and become established.

Speckled alder grows well on a variety of soils, including rocky till, sandy loam, gray forest soils, and muck. The range of tolerance to alkalinity or acidity could not be found, but is probably similar to that of European alder (*A. glutinosa* [L.] Gaertn.) and European speckled alder (*A. incana* [L.] Moench.), which grew well on Ohio spoil banks with a pH range of 3.4 to 7.7 (*Lowry et al 1967*).

In the oak-hickory region, flood plains commonly support stands of alders and willows; if undisturbed, these shrubs give way to American sycamore, elms, red maple, and sweetgum.

In northern forests, alders grow with willows and heath shrubs as well as tamarack, birches, aspens, and conifers (*Shelford 1963*).

About 80 species of plants were found growing in hazel alder stands in Pennsylvania, but silky dogwood, black willow, jewelweed (*Impatiens* spp.), and sensitive fern (*Onoclea sensibilis*) were the most characteristic (*Liscinsky 1972:35*). Blackberries, common chokeberry, American elm, goldenrod (*Solidago* spp.), bluegrass (*Poa* spp.), and asters (*Aster* spp.) were also common associates (*Liscinsky 1972:35*).

LIFE HISTORY

Individual alders bear male and female flowers on separate catkins. Flowering occurs in April-May on catkins formed during the preceding year (*Basset et al 1961*). Wind spreads the pollen. The seed matures in egg-shaped conelets. Seed occasionally ripens as early as August and is usually fully ripe by September or October (*U. S. Forest Service 1948*).

No information about the youngest or oldest seed-bearing age in speckled alder was found, and little is known about geographical differences in seed production. Other alder species bear seed when less than 10 years old and yield good seed crops almost every year. Winds spread the seeds during September through April. Spreading distances and the number of seeds produced per plant are not definitely known.

Alders reproduce from seeds, sprouts, layering, underground stems, and suckers. Seed is the primary source of new stands on freshly exposed soil. Perpetuation and spread of established stands result mostly from sprouting or other vegetative means.

Growth rates depend on many factors, including site conditions, competition, and type of growth (seedling or sprout). The largest speckled alder stand observed in a Michigan study was 26 years old and had stems averaging 5.5 inches d.b.h. and 25 feet tall (*Brickman 1950*). Clearcutting one aspen-balsam poplar-speckled alder stand in northern Michigan resulted in a dense stand of alder sprouts, which reached a maximum height of 6 feet the second year after cutting (*Day 1956*). Eight speckled alder stands in Ontario showed great

variation in height/age relationships among individual stems. The alder stands were growing on peat-covered clay soils and had originated after clearcutting black spruce. The tallest stem measured was 12 feet high and 13 years old, while the oldest was 30 years old and only 5.5 feet high. The average height of the speckled alder canopy varied from 3 to 6 feet, and the annual height growth declined steadily after 9 to 10 years of age (*Vincent 1964*).

Hazel alder stands in Pennsylvania had similar growth patterns. Stem growth was most vigorous from 1 to 8 years. Stems were more than 15 feet tall at 10 years of age, but height increased little during the next 10 years. After about 20 years of age, many stems began to die and few stems reached 30 years of age (*Liscinsky 1972:36*).

The alders are primary invaders of denuded areas with saturated soil. Both species grow more vigorously in full sunlight than in shade, and they are intolerant to intermediate in tolerance to shading. In general, sprouts are more tolerant of shade than seedlings (*Brickman 1950*) and speckled alder may be more tolerant than hazel alder.

Hazel alder stands in Pennsylvania seldom regenerate themselves, and they are usually replaced by trees (*Liscinsky 1972*). Speckled alder stands in northern Michigan are often overtopped by species such as balsam fir, northern white-cedar, and red maple, but it takes many years for these species to replace alder (*Brickman 1950*). In the same area, speckled alder is common beneath stands of tamarack, balsam poplar, aspen, and birch; and on some sites it may even replace aspen and balsam poplar (*Brickman 1950*). Speckled alder has been recommended for ornamental plantings in shady areas (*Kammerer 1934*).

USE BY WILDLIFE

Moose, muskrats, beavers, cottontails, and snowshoe hares feed on twigs and foliage. Deer browse alders, but most investigators rate the plant low in preference. Woodcock and grouse eat small quantities of buds, catkins, and seeds. Alder seeds are also eaten by some smaller birds, particularly redpolls and,

to a lesser extent, goldfinches (*Martin et al 1951*).

Alder is an important cover plant for woodcock and grouse. Woodcock use alder covers from early spring through fall for nesting, feeding, and resting. They prefer the edges more than centers of large evenage thickets (*Liscinsky 1965*). Alder stands were considered important grouse cover in Michigan, particularly where deer had eliminated other shrubs. Speckled alder provided the high shrub cover needed around grouse drumming sites (*Palmer 1963*). Beavers commonly use alders in dam construction.

PROPAGATION

It is usually best to collect and process local shrubs. Seed or seedling stock is seldom available commercially. Conelets can be harvested in September and October from standing or felled alders. Seeds are easily shaken out of dried conelets, but it is difficult to fan or screen out impurities (*U.S. Forest Service 1948*).

The following information pertains to hazel alder seeds gathered in Pennsylvania (*Liscinsky 1972:63*). When seed was plentiful it took 1 hour to pick 4 gallons of cones, which produced 1.6 pounds of seed (3.2 quarts). When seed was scarce, it took 1 hour to pick 1 gallon of cones, which yielded 0.4 pounds of seed. It took 2.5 gallons of cones to produce 1 pound of seed. Purity of seed ranged from 60 to 90 percent, and soundness ranged from 30 to 60 percent. Germination capacity varied from 2 to 60 percent. One pound of seed had a volume of 2 quarts and contained a total of 300,000 seeds.

The number of speckled alder seeds per pound is variable. Separate studies yield the ranges of 256,000 to 625,000 (*Van Dersal 1938*) and 473,000 to 890,000 (*U. S. Forest Service 1948*) seeds per pound. The latter group averaged 666,000 seeds per pound, 41 percent pure and 51 percent sound (*U. S. Forest Service 1948*). Yields of usable plants per pound of seed have been reported as 10,000 for speckled alder and 40,000 for hazel alder (*Van Dersal 1938*).

The easiest way to handle alder in the nurs-

ery is to sow fresh clean seed in November (*Heit 1968:15*). Seed should be broadcast or drilled in and lightly covered with either washed sand or sand mixed with hardwood humus. Either was superior to nursery soil or leaf litter for covering speckled alder seedbeds (*U. S. Forest Service 1948*). Seedbeds should be mulched for overwinter protection, but the mulch should be removed when germination begins in the spring. The beds should be kept moist and shaded until late summer of the first season (*U. S. Forest Service 1948*).

Seed may be planted in the spring if it is first stratified in moist sand or vermiculite for 60 to 90 days. Speckled alder seeds stratified for 2 months at 32 to 40° F. gave excellent germination within 10 days after sowing (*Daly 1966*). Hazel alder seeds stored at 41° F. for 206 days gave 30 percent germination, which was mostly complete 10 days after sowing. Keeping the seeds in complete darkness had no effect on percent or time of germination (*McDermott 1953*).

For long-term storage, seeds should be thoroughly cleaned, air-dried and refrigerated in sealed containers. Alder seeds kept in this manner at 34 to 38° F. were viable after 10 years (*Heit 1967e*).

Two- and 3-year-old seedlings should be used for field plantings; 1-year-old hazel alder stock had very low average survival in the field (*Liscinsky 1972:61*). Plantings succeeded on a variety of sites, but not on extremely dry soil. Heavy sod should be scalped back before planting; competition from dense herbaceous vegetation can cause planting failures.

Direct seeding of hazel alder in the field has been successful in Pennsylvania (*Liscinsky 1965, 1972*). Seedbeds prepared by disking produced 35 percent more seedlings than untreated plots, but good catches occurred even when seed was sown directly on sod. Cool, moist sites were best for direct seeding, and the sites closest to the stream produced the most seedlings. Generally, the best results were obtained when fall-collected seed was sown during the following February and March. Seeding rates were about ½ pint (¼ pound) per 100 square feet. Attempts to propagate hazel alder in the field from stem and root cuttings were unsuccessful (*Liscinsky 1972:61*).

MANAGEMENT

Alders, along with other desirable species, are good for reforesting various kinds of spoil banks. Alders are also ideal as streambank cover and for increasing the fertility of bottomlands. Fertility increase is from nitrogen-fixation by root nodules and from fallen leaves. The amount of nitrogen added to the soil varies, but in general the alders compare favorably with legume crops and black locust (Daly 1966, Lawrence 1958, Lowry et al 1967). European foresters plant alders beneath conifers to increase soil nitrogen and stimulate the growth of crop trees.

Alder stands can be established by planting seedlings or by direct-seeding on cool, moist sites. Where alders are present but suppressed, fire and most logging practices favor alder over competing species. Large stands of alders commonly form after spruce and fir are logged from wet ground.

Large stands are probably best managed for wildlife on a rotation of 30 years or less, based

on the time the alders require to reach maturity or grow so tall that they handicap hunters. Cutting schemes should provide patches of various age classes, well dispersed throughout the stand. A cutting cycle of approximately 25 years, with cutting at 4- to 5-year intervals, has been recommended for managing alder coverts for woodcock in Pennsylvania (Liscinsky 1972).

Overmature thickets can be opened up by clearcutting. Spring and winter cutting will result in the most rapid sprout growth; July and August cutting will produce the thinnest stands and least height growth (Brickman 1950). Stands overtopped by larger trees respond well to release cutting, but stumps of pole-size hardwoods should be poisoned to reduce sprouting. Competition from tree seedlings, particularly conifers, should not limit stump sprouting of alders.

Several formulations of the herbicides 2,4,5-T and 2,4-D effectively control alders when applied as stump, basal, or foliage sprays (Liscinsky, personal communication).

AMERICAN BITTERSWEET

Celastrus scandens L.

Also called Climbing, False, or Shrubby Bittersweet; and Waxwork.

By Jack I. Cromer

West Virginia Department of Natural Resources
Elkins

RANGE

American bittersweet occurs from southern Quebec to southern Manitoba and southward to Georgia, Alabama, Louisiana, Oklahoma, Texas, and New Mexico.

HABITAT

This vine grows under a diversity of climatic conditions, but no information about climatic optima or limits was found.

It is common along stream banks, in old fields, in low thickets, and in fencerows. It tolerates a variety of soil textures (sand, loam, and clay), but prefers soils with a nearly neutral pH (Wherry 1957). It grows well in partial shade or full sunlight, but best in sunny locations, either on banks or where the vines can ascend a supporting structure (Holweg 1964, Hosley 1938).

Associated plants in Minnesota were moonseed (*Menispermum canadense*), frost grape (*Vitis* spp.), and prickly ash (*Xanthoxylum americanum*) (Daubenmire 1936); and in Missouri redbud (*Cercis canadensis*), herbaceous mandrake (*Podophyllum peltatum*), goosegrass (*Eleusine indica*), and Miami-mist (*Phacelia purshii*) (Shelford 1963).

LIFE HISTORY

Greenish-yellow flowers appear in late May and June. On individual plants, flowers are mostly unisexual. The primarily female-flower plants usually have enough male flowers for fertilization (Hosley 1938), but plants of both sexes should be fairly close together to insure good fruiting (Holweg 1964). Fruits ripen in September and October; some may persist on the plants as late as March, although most drop before late winter (Petrides 1942).

Seed production starts at 3 years in vigorous plants growing in full sunlight (Spinner and Ostrom 1945), but may be delayed a year or longer in less vigorous plants. Good seed crops are commonly produced each year.

Bittersweet may reproduce by layering or from stolons.

Growth rate of plantings is variable; in Vermont, Delaware, and West Virginia, average lengths of 7-year-old stems ranged from 15 inches to 12 feet. Generally, stem growth averaged 12 to 30 inches in 3 years, 30 to 60 inches in 5 years, and about 6 feet in 7 years, with little additional growth afterwards (Edminster and May 1951).

On good sites, bittersweet is aggressive and competes well with other vegetation. However,

plantings along pasture fences are commonly browsed back to stubs whenever they are within reach of cattle (*Edminster and May 1951*). Plantings in New York were also retarded by browsing deer (*Smith 1962*) and rabbits (*Petrides 1942*).

USE BY WILDLIFE

Fruits, buds, and leaves are potential food for ruffed grouse, pheasants, quail, wild turkeys, and other birds. Rabbits and squirrels relish the fruits; rabbits and deer eat the leaves and stems.

The twining vines form excellent wildlife cover. Bittersweet, along with wild grape and elderberry, provides outstandingly acceptable nesting sites for hedgerow birds (*Petrides 1942*).

PROPAGATION

Bittersweet can be propagated easily from cuttings of mature shoots, layerings, or roots (*Fuller 1910*). Female plants are preferred as stock. Root cuttings, either softwood in summer or hardwood in fall and winter, have been used successfully (*Hosely 1938*).

Seeds can be collected in mid-September and later, as long as the fruit capsules hang on. They should be spread out and allowed to air-dry for 2 or 3 weeks. Cleaned seeds average 26,000 per pound (12,000 to 40,000). Average purity of commercial seed was 93 to 98 percent and soundness was about 84 percent (*U. S. Forest Service 1948*).

Seed dormancy is broken by pre-chilling for 2 to 6 months. Stratification in moist sand or peat for 90 days at 41°F. is recommended (*Barton 1939*). Seeds stored in a cool-damp basement gave no germination after 1 year, but seeds that had been air-dried and stored in sealed glass containers at 34 to 38°F. re-

tained excellent germination capacity after 4 to 8 years (*Heit 1967e*).

If stratification is impractical, seeds can be sown in the fall; however, emerging seedlings are susceptible to decay by soil-inhabiting fungi. For outplanting, 2-year-old seedlings are apparently best. At each planting site, all competing vegetation should be removed from at least 1 square foot (*Edminster and May 1951*) around the plant.

MANAGEMENT

Aside from having food and cover value for wildlife, bittersweet is a desirable ornamental and can also be used to control erosion. The fall leaf color is yellow, and the persistent orange fruits add attractive color to landscapes during fall and early winter. This species is especially well adapted for training over out-buildings and for climbing over walls, trellises, trees, and shrubs (*Hosely 1938*).

Plantings have generally survived well, and they spread by runners; but growth and fruit production have often been retarded by rabbit and deer browsing (*Smith 1962*). The high palatability of this plant requires caution in selection of planting sites. The best use of bittersweet may be as a filler among plantings or natural growths of other shrub species (*Edminster and May 1951*).

Aggressiveness of bittersweet should also be considered, because rapid spread on exceptionally favorable sites may lead to control problems. No specific information about control methods was found.

MISCELLANY

The fruiting branches are valuable for commercial use or as home decorations; however, bittersweet fruits are thought to be poisonous if eaten by humans (*Grimm 1952*).

BLUEBERRIES

LOWBUSH BLUEBERRY, *Vaccinium angustifolium* Ait. Also called Lowsweet, Dwarf or Sugar Blueberry, Sweethurts, and Strawberry-Huckleberry.

HIGHBUSH BLUEBERRY, *Vaccinium corymbosum* L. Also called Tall or Swamp Blueberry, Wortleberry, and Seedy Dewberry.

By Robert Rogers

*Rutgers University
The State University of New Jersey
New Brunswick*

RANGE

Lowbush blueberry, the more northerly species, occurs from the tundra in Canada, throughout the New England States, in the Piedmont and mountain areas of Pennsylvania and New Jersey, and south down the Appalachian Mountains to northern Virginia (*Darrow and Moore 1966*). Highbush blueberry occurs along the Atlantic Coast from eastern Maine to northern Florida and also in the Great Lakes region, including northern Indiana, northern Ohio, northwestern Pennsylvania, southern Wisconsin, and southern Ontario (*Darrow and Moore 1966*).

HABITAT

Both species are acclimated to climatic extremes in the southern part of the region. In the northern part of the region, growth of highbush blueberry is limited by growing season and extreme winter temperatures. A minimum adequate growing season of 160 days is required for highbush blueberry (*Chandler*

1943). Temperatures below -20°F result in winter-kill, and temperatures below -30°F will kill plants to ground or snow level (*Cain and Slate 1953*). Although lowbush blueberries border the tundra in Canada, they are favored by a minimum growing season of 125 days (*Chandler 1943*). Lowbush blueberry is found farther north than highbush blueberry, perhaps because its prostrate form accommodates it to a protective snow cover (*Eaton 1949*). Summer temperatures in excess of 120°F can cause mortality in young plants (*Kender and Brightwell 1966*).

Blueberries, like most members of the Heath family, prefer acid soil. They make their best growth on light, well-drained acidic soils high in organic-matter content (*Kender and Brightwell 1966, Van Dersal 1938*). Soils developed from limestone are not conducive to good blueberry growth.

Lowbush blueberry is the typical upland blueberry in the Appalachian Mountain areas from West Virginia north to the New England States. Stony, silt, and clay loam soils devel-

oped from sandstones, shales, and glacial drift commonly support colonies of lowbush blueberry. These colonies often occur on dry, rocky, open upper slopes and ridgetops (Braun 1950, Fernald 1950, Darrow and Moore 1966, Van Dersal 1938).

Highbush blueberry is frequently found at lower elevations along the Atlantic Coast and in the Great Lakes region, where it occurs along the edges of swamps, within open areas of moist woodlands, and occasionally in moist upland fields (Fernald 1950, Darrow and Moore 1966). Highbush blueberries grow: on soils consisting of sandy loams developed on Coastal Plain sands and clays in Maryland, Delaware, southern New Jersey, Long Island, and southeastern Massachusetts; sands and loamy sands developed on glacial drift; and on stony and gravely silt and clay loams developed on glacial drift, which frequently have a hardpan in the soil profile (Beckwith and Coville 1931, Johnston 1942, Trevett 1962, Van Dersal 1938).

Heavy soils with poor drainage prevent root penetration and thereby increase the probability of frost heaving; and coarse sandy soils present droughty conditions during summer months despite normal rainfall. During dry periods, blueberries are hindered in water uptake because they lack root hairs (Ballinger 1966, Kender and Brightwell 1966). Optimum growth of blueberry occurs when soil pH is between 4.3 and 4.8 (Kender and Brightwell 1966). However, blueberries are commonly found on soils having pH values ranging from 3.5 to 5.5, although soil pH values higher than 5.2 seem to limit growth (Ballinger 1966).

Blueberries are relatively intolerant to shade, and tend to flourish in open areas. Shading reduces vegetative growth and flower-bud formation in both species (Hall 1958, Reiners 1967). Throughout the region, both species are found in association with other members of the Heath family, especially mountain laurel, huckleberry, and azalea. On moist sites along the Atlantic Coast, highbush blueberry may grow with alder, gray birch, blackhaw, arrowwood, silky dogwood, and red and black chokeberry. It may be succeeded by red maple, blackgum, ash, sweetgum, elm, yellow-poplar, pin oak, white oak, black oak, and

shagbark and mockernut hickories. The chief shrub competitor of lowbush blueberry in the northern forest is mountain laurel (Hall 1963, Shelford 1963). Invasion of the shrub layer by pioneer tree species rapidly reduces the abundance of lowbush blueberry (Shelford 1963).

LIFE HISTORY

Blueberry flowers appear with the leaves in spring. Flower buds are formed during the previous season, and the pinkish-white bell-shaped flowers are arranged in elongated clusters (Eck 1966, Gleason 1963b, Shutak and Marucci 1966). Insects, specifically wild and honey bees, are the chief pollinating agents of highbush and lowbush blueberries. Both fruit yield and fruit size are a function of the bee population in a given area (Martin 1966; Marucci 1966; Shutak and Marucci 1966). Highbush blueberry fruit matures from 50 to 90 days after bloom, while lowbush blueberries mature from 90 to 120 days after bloom. Lowbush blueberry flowers from April to June. The fruit is available from July to September (Van Dersal 1938). Highbush blueberry flowers from May to June, and the fruit is available from June to August (Kender and Brightwell 1966, Van Dersal 1938).

Highbush blueberry plants bear fruit when 8 to 10 years old, but some plants may bear fruit as early as the third year (Taylor 1962). An established mature bush can be expected to yield 8 to 10 pints of fruit per year; however, fruit production may vary with local conditions (Taylor 1962). Fruit yield of lowbush blueberry is usually lower than that of highbush blueberry because of relatively poor blossom set. This reduced ability to set blossoms is attributed to various degrees of self-sterility in large clones (Aalders and Hall 1961). Also, velvet-leaf blueberry pollen is incompatible with lowbush pollen. If velvet-leaf blueberry (*V. myrtilloides* Michx.) is present in the stand, lowbush pollen will be diluted and fruit production will be reduced (Aalders and Hall 1961).

Blueberries reproduce from seeds, sprouts, underground stems, and suckers. Seed is disseminated chiefly by animals, from June through September. On sites previously uninhabited by blueberry plants, seedlings become

established in open areas on exposed mineral soils. Highbush blueberries are usually crown-forming plants 6 to 15 feet high, which may consist of several stems. Individual plants sometimes tend to sucker at the base and form extensive colonies. Lowbush blueberries may form extensive colonies by means of underground stems (*Camp 1945*). Growth of both species is comparatively slow even on the best sites. Highbush blueberry will attain a height of 6 to 15 feet in 8 to 10 years (*Taylor 1962*). I found no growth-rate figures for lowbush blueberry. The maximum height growth for lowbush blueberry is about 2 feet.

Both species are intolerant to shade and are found in open woods or clearings. Encroachment by shade-tolerant species restricts blueberries to openings in the stand or quickly relegates them to suppression and eventual elimination if no openings are provided. After fire or logging, lowbush blueberry will become reestablished from roots within the area (*Hall 1955*).

USE BY WILDLIFE

Blueberries are important to American wildlife (*Martin et al 1951*). For several species of grouse, blueberries are among the most important summer and early fall foods. They also are part of the diet of other upland game birds such as bobwhite, wild turkey, and mourning dove. Many song birds, including the scarlet tanager, bluebird, and thrush, also feed on blueberries. Fur and game mammals such as the black bear, red fox, cottontail rabbit, eastern and spotted skunk, and the fox squirrel utilize the fruit, twigs, and foliage of the blueberry. Part of the diet of the white-footed mouse consists of blueberry fruit. White-tailed deer browse the branches and foliage and eat the fruit (*Martin et al 1951; Van Dersal 1938*). Because of the dense shrubby growth often produced by highbush blueberry, and its high food value, it can be a desirable hedgerow plant, providing both food and cover for a variety of song birds, ruffed grouse, and cottontail rabbit.

PROPAGATION

Seed and stock are available commercially for highbush blueberry, but are not commonly available for lowbush blueberry. Highbush blueberries are commonly propagated by hardwood cuttings obtained from healthy shoots of the past season's growth, ¼-inch diameter or less. Shoots are gathered in the spring just before bud growth starts—15 March to 10 April in New Jersey (*Doehlert 1953*). Fruit buds are undesirable on shoots used for cuttings and should be rubbed off if present (*Mainland 1966*). Shoots should be cut into pieces 3 to 5 inches long, using either a sharp knife or pruning shears. The cut is usually made below the bud for small quantities of twigs, but for large quantities a bench saw is used and bud position is ignored.

The cuttings should be treated with a fungicide and set in either a box frame, solar frame, or open frame containing an equal mixture of sand and horticultural peat (*Doehlert 1935*). About 75 percent of the cuttings should root. Rooting has taken place when the terminal bud begins to green. Liquid fertilizer (either 15-30-4 or 13-26-13, at 1 ounce of concentrate per 2 gallons of water) can be applied to rooted cuttings during the summer, but its use should be discontinued in time to allow adequate tissue hardening—mid-August in New Jersey (*Doehlert 1953*). Young plants can be left in the propagating beds over winter, or they can be transplanted into nursery beds in early fall to allow adequate root growth before winter.

Seeds are commonly used to propagate lowbush blueberry; this method may also be used to propagate highbush blueberry. Berries should be collected when ripe, and chilled at 50°F for several days. Seeds can be removed from the berry by shredding in a food blender for 30 seconds (*Morrow et al 1954*). Sound seeds will settle to the bottom. Stratification may be beneficial in hastening germination. Seeds should be planted in a mixture of sand and horticultural peat. Seedlings will begin to emerge in a month and will continue to emerge for a long period thereafter. Seedlings can be transplanted to other flats after they are 6 to 7 weeks old. Seed may be kept under normal refrigeration and will remain viable for

as long as 12 years (*Darrow and Scott 1954*).

Young highbush blueberry plants can be transplanted into the field after the first season. Spacing between plants ranges from 4 to 8 feet between plants and 8 feet between rows. Lowbush blueberries may be established in barren areas by using a golf-hole cutter to remove sod containing roots from a vigorous stand and transplanting it to the desired area (*Hitz 1949, Eggert 1955*). The distance between holes should be no more than 8 inches. Blueberries are exacting in their site requirements and attempts at establishment on less favorable sites have been disappointing (*Kender and Brightwell 1966*). If blueberries are present naturally, in most situations a desirable stand can be cultured.

MANAGEMENT

Lowbush blueberries are often found in the undergrowth of open forest stands in a suppressed stage in which they rarely flower and bear fruit. Removal of competing vegetation

will stimulate the blueberry's root system and increase the vigor, abundance, and fruit yields of the plants (*Hall 1955, 1963*). For maximum flowering and fruiting of blueberries, competing vegetation should be reduced to a minimum. This can be accomplished by shallow cultivation or, in the case of lowbush blueberries, light burning in the spring once every 2 or 3 years (*Chandler 1943, Shutak and Marucci 1966*). Care must be taken to avoid fires hot enough to destroy the roots from which new shoots will appear. Pruning is beneficial to both species because fruit is borne abundantly on 1-year shoots rather than on old mature branches.

When enlarging a field from an adjoining woodland, it is advisable to clear the land slowly by cutting and burning a strip 2 or 3 feet wide each year. The overstory must be removed gradually over a period of several years (*Hall 1955*). The herbicides 2,4-D and 2,4,5-T applied on foliage, stems, or stumps will control blueberries.

BRAMBLES

Also called Blackberry, Dewberry, Groundberry, and Raspberry.

ALLEGHENY BLACKBERRY, *Rubus allegheniensis* Porter

BLACKCAP RASPBERRY, *Rubus occidentalis* L.

CANADIAN or THORNLESS BLACKBERRY, *Rubus canadensis* L.

FLOWERING RASPBERRY, *Rubus odoratus* L.

NORTHERN DEWBERRY, *Rubus flagellaris* Willd.

RED RASPBERRY, *Rubus strigosus* Michx.

SWAMP GROUNDBERRY, *Rubus hispidus* L.

By Earl L. Core

West Virginia University
Morgantown

SPECIES

No one knows how many kinds of brambles there are in eastern North America, but more than 500 have been named. Classification of the brambles has been thoroughly treated in other publications (*Bailey 1941-45; Bailey 1947; Bailey 1949; Davis et al 1967-70*).

Blackberries have erect stems, usually angled in cross-section, and armed with large sharp spines. There are usually five leaflets. Dewberries and groundberries have prostrate, trailing stems. Raspberries have erect canes, usually white-powdered, round in cross-section, and often without spines or with weak hairlike spines. There are usually three leaflets. Also, in raspberries the fruit is thimble-like or cap-like, the dry receptacle remaining

on the bush; while in blackberries the receptacle itself becomes fleshy and is removed with the fruit.

RANGE

Brambles are found throughout the Northeast. Those listed above are common and widespread, but many other important species occur (*Davis and Davis 1953, Fernald 1950, Strausbaugh and Core 1953*). Red raspberry, Canadian blackberry, swamp groundberry, and northern dewberry are common in the higher elevations and northward, while Allegheny blackberry, blackcap raspberry, and flowering raspberry are more abundant at lower elevations and latitudes (*Shelford 1963*).

HABITAT

Typically the brambles are plants of old fields and woodland clearings. The various species are acclimated to practically all the extremes that occur in the Northeast.

Brambles grow well in a great variety of soils and topographic conditions. Red raspberry is frequent in acid barrens at the higher elevations, where it grows with other acid-loving plants such as blueberries, huckleberries, menziesia, azaleas, mountain laurel, great laurel, and teaberry. Swamp groundberry is widespread in mountainous areas in low boggy places or upland mossy lands. It is associated with cranberries in sphagnum bogs or with teaberry and other plants in mossy uplands.

There are numerous other similar species of groundberries. Northern dewberry is most common northward, but despite its name, ranges south to Georgia, trailing in dry fields and along road banks.

Blackberries generally occupy an intermediate temporary stage in old fields, associated with hawthorns, crabapples, sassafras, fire cherry, black cherry, and other pioneer trees. They are quickly eliminated as overgrowing trees provide too much shade. Allegheny blackberry and many other blackberries are common in dry places from lowlands to uplands, open places in woodlands, along roadsides, in old fields, fence-rows, clearings, and thickets. Canadian blackberry, one of the taller and later-flowering species, is very common in woods, old fields, cool hollows, and along roadsides, mostly in the mountainous regions.

Flowering raspberry is abundant in shady places in woods, along roads and in thickets. Blackcap raspberry is common in woods, borders, fields, fence-rows, and thickets. It is often associated with black walnut trees, a situation unfavorable to many plants. In a study of succession on abandoned farm fields in southern Illinois, blackcap raspberry first appeared 3 years after abandonment and was still present after 40 years. It remained important as long as fields were open and decreased with the increase of woody vegetation. Sassafras, persimmon, and winged sumac were among the first woody invaders (*Bazzaz 1968*).

LIFE HISTORY

Brambles are perennial; in most species the root lives for many years and the stems live for only 2 years. First-year stems are usually sterile and have leaves unlike those of the second year. Flowers and fruit are borne the second year. In most species, flowers appear in May and June, and fruits are ripe in early summer. In the Canadian blackberry, however, ripe fruits persist into September. No figures on seed production per plant were noted. The seeds are spread mostly by birds.

Brambles reproduce from seeds, sprouts, layers, and underground stems. Vegetative propagation is the primary source of development of the dense colonies often seen in old fields. New colonies on freshly exposed areas develop from seeds. Growth of most brambles is more vigorous in full sunlight than in shade. Blackberries grown in shade are often nearly or quite thornless, but produce few fruits. In full sunlight the thornless habit disappears, but fruit production is greatly enhanced. Raspberries, in contrast, seem to do better in partial shade. In the Southeast their habitat preference often puts the brambles in direct competition with Japanese honeysuckle.

USE BY WILDLIFE

Blackberries and raspberries stand at the top of summer foods for wildlife. Even dried berries persisting on the canes are eaten to some extent into fall or early winter; the principal use, however, is while the fruits are juicy. Nearly all species are palatable to human tastes, and probably are equally so to wildlife (*Chapman 1947d*). Another important factor is the widespread availability of brambles in all parts of the Northeast—indeed, in nearly all parts of the United States and Canada.

Birds are especially prominent as users of the fruits. Blackberries and raspberries are important to game birds such as grouse, ring-necked pheasant, and bobwhite quail, and to such common songbirds as catbird, cardinal, yellow-breasted chat, pine grosbeak, robin, orchard oriole, summer tanager, brown thrasher, thrushes, and towhees. Blackberry and raspberry fruits are also important foods of raccoons, chipmunks, and squirrels, as well as

other small animals. Deer and rabbits make extensive use of leaves and stems (*Martin et al 1951*).

Because of their habit of forming extensive colonies the various species of brambles have much value as cover for wildlife. The thorny canes create nearly impenetrable thickets where birds, rabbits, and other animals find relative security. In winter, rabbits nibble the stems while at the same time finding security from enemies. Colonies of brambles are common nesting sites for small birds (*Martin et al 1951*).

PROPAGATION

Horticultural varieties of blackberry and raspberry are readily available from nurseries. Dewberry or groundberry stock is also available, although less readily. Since commercial culture is usually for fruit production, nurseries propagate brambles vegetatively from tip layers, root cuttings, and suckers.

Brambles tolerate a wide range of soil types, textures, and pH values; but adequate soil moisture is critical for fruit production. Commercial stands produce best on deep sandy loam with a large supply of humus. Transplanting is done during the dormant season, usually in early spring, and transplanting after growth has started is avoided. Growing stock, propagated in any manner, is generally cut back to ground level when transplanted (*Mecartney 1945, Darrow and Waldo 1948*).

Tip layering is a simple, naturally occurring process recommended for raspberries (*Mecartney 1945*). Raspberry canes grow so that by late August or September the tips reach the ground, and many of these will form new plants naturally. To insure large numbers of new plants, cane tips should be set 4 to 6 inches straight down into the ground, and the soil should be formed around them. Canes are ready for layering when the tips have elongated so that a bare portion extends 3 to 6 inches beyond the last small set of leaves. Rooting will begin in about a week, and rooted tips can be cut from the parent plant and transplanted the next spring (*Darrow and Waldo 1948*).

Blackberries send up suckers, and new plants are usually obtained by digging and

transplanting these suckers (*Mecartney 1945, Darrow and Waldo 1948*). Root cuttings provide another simple method of propagating blackberries. Roots $\frac{1}{4}$ inch or more in diameter are dug in the fall or early spring, and divided into pieces 3 inches long. These are planted horizontally in trenches about 3 inches deep, and by the following fall new plants will have developed (*Darrow and Waldo 1948*).

Brambles can be propagated from seed in the field or nursery. Blackberry seeds have extremely hard coats. Untreated seeds germinated over a period of 3 to 5 years, with very little germination the first year (*Heit 1967b*). To obtain maximum germination the first year, the seeds must be treated so that water can penetrate the coat. Cleaned seed should be soaked in concentrated sulphuric acid for 50 to 60 minutes at 75 to 80°F (*Heit 1967a*). Shorter treatments are less effective and longer ones will cause injury. Seeds should be thoroughly washed immediately after acid soaking, and planted in late August or early September. In nurseries seeds are sown on peat moss or light soil; in the field they should be sown on mineral soil.

Raspberries do not have the extreme hard seedcoat of blackberries. A long warm-and-cold stratification period will usually give good germination, and fresh cleaned seed may be sown in late summer. However, better and more uniform germination can be obtained if raspberry seeds are given a 10- to 30-minute sulphuric acid treatment before sowing in late summer (*Heit 1967, pt. 7*). Treated blackberry and raspberry seeds may be planted in early spring, but they require a 1- to 3-month cold stratification period at 34 to 38°F. This stratification treatment is recommended for seeds of all brambles that are to be spring-planted (*Heit 1967b*).

MANAGEMENT

Besides providing food and cover for wildlife, brambles have great erosion-control value. Many species form dense thickets rapidly, and some form dense mats on the ground. Most species grow satisfactorily in very barren and infertile soils; and they invade and rapidly occupy burns, eroded areas, old fields, and

logged areas (*Barrett, Farnsworth, and Rutherford 1962; Van Dersal 1938*). Because there are so many species and they are so abundant, it is seldom necessary to establish brambles. Direct-seeding would be justified if it were important to establish cover quickly or to insure development of the desired species in a new opening.

Openings are the key to managing bramble patches, because invading trees and shrubs quickly eliminate most brambles. Bramble patches can be encouraged or rejuvenated by removing overhead shade, mowing, light burn-

ing, or deep cultivation. Mowing and burning stimulate sprouting in addition to removing competing vegetation. Deep cultivation (6 to 9 inches) cuts the roots of existing brambles, and causes the formation of large numbers of sucker plants.

Benzabor (disodium tetraborate pentahydrate 54.50 percent and disodium tetraborate decahydrate 35.5 percent with trichlorobenzoic acid 8 percent), applied with hand-operated mechanical spreaders or blast guns in early spring and summer, is effective against brambles (*Waestemeyer 1963*).

CHECKERBERRY WINTERGREEN

Gaultheria procumbens L.

Also called Checkerberry, Grouse Berry, Mountain Tea, Partridge Berry, Teaberry, Winterberry, Wintergreen, and many other common names (*Krochmal et al 1969*).

By Sadie L. Robinette

*West Virginia University
Morgantown*

RANGE

Checkerberry wintergreen or teaberry occurs from Newfoundland to Manitoba south to Virginia, Kentucky, and Minnesota, and in the mountains to Georgia (*Gleason 1963c*).

HABITAT

Checkerberry wintergreen is hardy throughout the Northeast. It requires acid soil and usually grows within the pH range of 4.0 to 6.0 (*Wherry 1920 and 1957*). In a mature beech-maple forest in Ohio, checkerberry wintergreen was found growing where the pH of the soil ranged from 3.5 to 6.9 on the surface to 4.0 to 6.9 below the surface. Its distribution was independent of pH value within these ranges (*Stone 1944*). However, a pH of 4.5 to 6.0 has been reported as optimum for the growth of checkerberry wintergreen, with 7.0 the maximum pH it will tolerate (*Spurway 1941*).

As long as the soil is acidic, checkerberry wintergreen will grow well on many soil types, including peat, sand, sandy loam, and coal spoil banks. It will tolerate site conditions ranging from dry to poorly drained (*Wilde 1933*).

Checkerberry wintergreen is commonly found in heath shrub communities that are characteristic beneath many forest types, including both pine and hardwoods in New England, and jack pine and spruce-larch forests in the Lake States (*Braun 1950, Hosley 1938, Kittredge 1934*). It also occurs in bogs and as an invader of old fields in many parts of the region (*Strausbaugh and Core 1958:708*). Mountain-laurel, rhododendron, azaleas, blueberries, huckleberries, and trailing arbutus are the most common heath associates of checkerberry wintergreen.

In Maine, checkerberry wintergreen is abundant in grouse coverts in both upland and lowland hardwoods and mixed hardwood-conifer stands. The tree associates are yellow birch, sugar maple, beech, white birch, aspen, and spruce; and the ground cover associates include bunchberry, clover, partridgeberry,celandine, and shinleaf (*Brown 1946*). In Massachusetts, checkerberry wintergreen colonized abandoned farmland along with common juniper, flowering raspberry, and sumac (*Hosley and Ziebarth 1935*). It also volunteered on coal spoil banks in central Pennsylvania, where it formed part of the shrub layer beneath aspen-fire cherry stands. The common

shrubs growing with it were sweetfern, Allegheny blackberry, smooth and staghorn sumac, and prairie willow (*Bramble and Ashley 1955*).

LIFE HISTORY

Checkerberry wintergreen's small, white, perfect flowers are borne from June to September. The bright red fruit ripens in the fall, and often remains on the plant until early the next summer (*U. S. Forest Service 1948:187*). The fruit is rather dry and consists of fleshy flower parts surrounding a dry capsule, which contains many minute seeds (*U. S. Forest Service 1948*). There are approximately 2,800 fresh fruits per pound, and about 3,000 dried fruits per pound (*Swingle 1939, U. S. Forest Service 1948, Van Dersal 1938*). Individual plants usually bear 2 to 6 berries.

I found no information concerning the longevity of this perennial plant, or the age at which it first produces fruit. The growth rate is slow, and there is little hazard of spreading from planted specimens (*Ruffner 1965*).

Checkerberry wintergreen reproduces vegetatively from root suckers (*Hosley 1938*). Seeds are probably the source of new plants colonizing old fields, and birds may disseminate the seeds.

Checkerberry wintergreen is shade-tolerant, but most fruiting occurs in openings (*Edminster 1947:120*). Heavy fruiting often follows cutting of timber (*Hosley 1938*).

USE BY WILDLIFE

Checkerberry wintergreen is not taken in large quantities by any species of wildlife, but the regularity of use enhances its importance (*Edminster 1947, Martin et al 1951*). It is a year-round fruit producer, and one of the few sources of green leaves in winter (*Brown 1946, McAtee 1914*).

White-tailed deer and ruffed grouse are the most important users of checkerberry wintergreen. Grouse eat both fruit and leaves throughout the year, and in some localities teaberry is one of the most important grouse foods (*Brown 1946, Edminster 1947, Hosley 1938*). White-tailed deer browse teaberry throughout the region, and in some localities

it is an important winter food (*Hosley and Ziebarth 1933, Watts 1964*).

Other animals that eat checkerberry wintergreen are wild turkey, sharp-tailed grouse, bobwhite quail, ring-necked pheasant, black bear, white-footed mouse, and red fox (*Hosley 1938, Martin et al. 1951, Van Dersal 1938*). Teaberries are a favorite food of the eastern chipmunk, and the leaves are a minor winter food of the gray squirrel in Virginia (*Dudderar 1967, Van Dersal 1938*).

PROPAGATION

Checkerberry wintergreen has been cultivated at various times in the past, but seed and growing stock are not usually available from nurseries (*Rehder 1940:739*). Commercial seed consists of the dried fruits, which number about 3,000 per pound. Seed may be collected locally at any time in the fall after ripening (usually early September). Seed is extracted by drying the fruit until it is brittle and powdery and then rubbing it through a 30-mesh screen (*U. S. Forest Service 1948*). The number of clean seeds per pound has been reported as 163,000 and 2,870,000 to 4,840,000 (*Swingle 1938, U. S. Forest Service 1948*).

The seed has a dormant embryo, so it must be either planted in the fall or stratified before spring planting. Probably the easiest way to propagate small quantities of teaberry is by sowing whole fruits soon after collection in the fall. Fruits should be sown outdoors in moist, acid soil in a shady location. Seedbeds should be protected from rodents over winter.

For spring planting, seed should be cleaned soon after collection, and then stratified for 30 to 75 days at 41°F before planting. Because of its minute size, clean seed should be scattered on or pressed into peat, and then protected with a pane of glass placed about 4 inches above the soil. Seedbeds should be shaded. The soil should be moist, porous, and acidic; mixtures of sand and peat are usually used (*U. S. Forest Service 1948*).

Checkerberry wintergreen can be propagated at any time during the spring and summer by simple layering. It reproduces vegetatively from root suckers, and new plants may be obtained during the spring or fall by digging and transplanting suckers. Clumps of

checkerberry wintergreen can also be divided and transplanted during the spring or fall (Bailey 1950, Laurie and Chadwick 1931).

Establishment in the field should be limited to acid sites, and plants will do best in partial shade.

MANAGEMENT

Checkerberry wintergreen is ordinarily plentiful in the woodlands of the Northeast, and no special care is needed to keep it growing (Hosley 1938). Fruit production can be stimulated by thinning timber stands and removing overtopping vegetation.

Checkerberry wintergreen is recommended to the suburban gardener as an ornamental and for attracting songbirds (Mason 1945, McAtee 1914 and 1936). It can be planted

under taller shrubs and in other partially shaded acid sites. Attractive groups of ground cover plants can be formed from checkerberry wintergreen, partridgeberry (*Mitchella repens*), bearberry (*Arctostaphylos uva-ursi*), bunchberry (*Cornus canadensis*), and Canada beadruby (*Maianthemum canadense*) (Mason 1945). Song birds will eat the fruits year-round, particularly during winter when few other fruits are available.

Checkerberry wintergreen was controlled by droplet spraying of the foliage with D-T, an equal mixture of 2,4-D and 2,4,5-T. A D-T mixture was more effective than 2,4-D alone. A 0.25-percent concentration of D-T killed checkerberry early in the growing season, but a 0.5-percent solution was more effective later in the summer (Egler 1949).

CHERRIES

COMMON CHOKECHERRY, *Prunus virginiana* L. Also called Black Chokecherry or Chokeberry, Cabinet Cherry, California Chokecherry, Caupulin, Cerisier, Chokecherry, Eastern Chokecherry, Rum Chokecherry, Western Chokecherry, Whiskey Chokecherry, and Wild Black Cherry.

By James R. Vilkitis

*University of Massachusetts
Amherst*

RANGE

Chokecherry grows from the Arctic Circle to Mexico and is one of the most widely distributed shrubs or small trees of North America. It occurs from Newfoundland and eastern Quebec across the continent to British Columbia, south to California, Arizona, New Mexico, Kansas, Missouri, Illinois, Indiana, Maryland, and Maine, and also southward in the Appalachians to parts of Kentucky, Virginia, North Carolina, and Georgia (*Little 1953*). In the mountains, in West Virginia at least, chokecherry has a scattered distribution (*Strausbaugh and Core 1952-64*).

HABITAT

Chokecherry is a hardy plant that, once established, defies northern extremes of climate. It occupies adverse sites such as moving sand dunes (*Schlatzer 1964*) and frost pockets where temperatures drop to 40° F below zero (*Harlow 1957*).

Occurring commonly in almost all soils of the Northeast, chokecherry can be found in a wide variety of habitats, from rocky hills and sand dunes to borders of swamps. It is even

found on the spurs of Mt. Katahdin, Maine, at an elevation of 4,000 feet (*Mathews 1915*). Chokecherry sometimes occurs in open woodlands, but it is more often associated with old fields, fence rows, roadsides, river banks, forest margins, and waste-corner thickets of farms. The species grows best in rich, well-drained, moist soil with ample sunlight, but it is also found in the shade on poor, dry soils (*Van Dersal 1938*). Optimum soil pH was reported as 6.0 to 8.0 (*Spurway 1941*).

Throughout its entire range, chokecherry is found in nearly all wooded areas (*Harlow 1957, Rogers 1906*). In the moving, slightly acid sand dunes it is a pioneer species associated with *P. besseyi*, *P. serotina*, *Pyrus baccata*, *Spiraea billiardii*, and *Lonicera ledebourii* (*Schlatzer 1964*). In dune depressions and sand flats it grows with *Carex pensylvanica* var. *digyna*, *Symphoricarpos occidentalis*, *Rosa woodsii*, and *Agropyron* spp. (*Hulett et al. 1966*). In the Northern Great Plains, chokecherry grows in shelter belts in combination with *Ulmus pumila*, *Fraxinus pennsylvanica*, *Acer negundo*, and *Prunus americana* (*George 1936*). On moist sites it is found with *Crataegus douglasii*, *Amelanchier florida*, *Rosa* spp., and *Symphoricarpos* spp. (*Shelford 1963*).

LIFE HISTORY

The white, densely elongated clusters of strongly-scented flowers bloom from April to July. In northern areas the flowers open later. The thick-skinned, edible fruit is about 5/16 inch in diameter. It ripens from July to September but remains astringent until ripe. Typically, the lustrous clusters of red or amber fruit turn dark red to purplish black at maturity. However, some varieties of chokecherry have different fruit colors. For example, in *P. virginiana* var. *leucocarpa*, the fruit is canary yellow when mature. Fruiting is abundant in most years, but production per plant is unknown. No information was found regarding seed-bearing age of trees.

Birds and mammals are the chief means of seed dispersal. Pits are dropped by birds throughout the fruit-bearing season and later. Primary reproduction of chokecherry is through seed. Once established it grows rapidly and often forms dense thickets of suckers and sprouts from an extensive lateral root system. (Brown 1922, Otis 1960, Van Dersal 1938, Vines 1960).

In most of its range chokecherry is a tall shrub. Only under the most favorable climatic and soil conditions does it become a small tree, 20 to 30 feet high, and it rarely exceeds 8 inches dbh.

Chokecherry is a very competitive shrub, due to its tolerance of adverse climatic and site conditions such as cold temperatures, shade and drought, and its ability to sprout prolifically. The adaptability of chokecherry is indicated by its exceptionally wide geographic distribution. However, chokecherry is subject to many disease and insect attacks, notably black knot disease (Hepting 1971, Hosley 1938) and defoliation by tent caterpillars.

Chokecherry is a host of the apricot ring pox virus, twisted leaf in sweet cherry (Lott and Keane 1960), and the notorious X-disease virus that infects peach and cherry trees (Gilmer et al. 1954, Wolfe 1955). Infected trees can be symptomless. X-disease spreads rapidly and can ruin an orchard in 3 or 4 years. This disease has caused considerable damage to peach orchards in New York since 1938 (Palmiter and Hildebrand 1943). It has been reported in the Maritime Provinces (Callahan

1964), Wisconsin, Michigan, Pennsylvania, and Connecticut. In areas where chokecherry is rare, as along Lake Ontario, X-disease is unknown (Parker and Palmiter 1951).

USES

Good crops of fruit are born in most years (Vines 1960), and about 70 species of game or song birds seek out fruits as soon as they become available (Bump et al 1947, Longenecker and Ellarson 1960, Van Dersal 1938). Chokecherries are readily eaten by ruffed grouse through the fall till December, but may be less important locally than pin or black cherries (Edminster 1947). The fruits are also eaten by small mammals (Grimm 1951), and the buds and twigs are browsed by ruffed grouse during winter (Phillips 1967). Rabbits have little taste for the bitter twigs of chokecherry (Harlow 1957), but repellents may not keep them from eating the bark (Detroux and Fouarge 1952, Vines 1960). Chokecherry stems ranked fairly high in winter feeding of cottontails in Connecticut (Dalke and Sime 1941).

In northern forests during winter, white-tailed deer and snowshoe hares eat chokecherry, but utilization differs with locality. In southern forests use of cherry species is low (Taylor 1961). Moose on winter range in Wyoming showed a high preference for chokecherry (Harry 1957), and black-tailed deer in Utah used it as a summer staple (Smith 1952).

Chokecherry has fair cover value for small mammals and nesting birds, particularly where it forms thickets (Longenecker and Ellarson 1960) but is of questionable value for landscaping, because of insect and disease susceptibility. Erosion control and shelterbelts are other important uses. And in some instances the fruit is eaten by humans; it makes a jelly with an almond-like flavor (Hosley 1938).

PROPAGATION

Because of the genetic variability of chokecherry and its wide geographic range, seed should be collected or purchased near the area of planting to insure local adaptability and

prevent introduction of strains that may be undesirable.

Seed can be gathered in August to September, either from the ground or by flailing fruit from the trees onto ground cloths. Cleaned seed is sometimes available commercially, and samples have proved 97 percent pure and 94 percent sound (*U. S. Forest Service 1948*). Reported numbers of cleaned seed per pound averaged 5,800, ranging from 3,000 to 8,400 (*Engstrom and Stoeckeler 1941, U. S. Forest Service 1948, Van Dersal 1938, Vines 1960*). Yields of clean seed per 100 pounds of fruit averaged 16 pounds, ranging from 7 to 24 pounds (*Swingle 1939*).

Optimum seed storage conditions are unknown, but good results were obtained from sealed dry storage at 26°F (*U. S. Forest Service 1948*), and seeds of pin cherry have kept for as long as 10 years when stored in sealed containers at 34 to 38°F. Temperatures warmer than about 40°F would probably reduce viability.

Sowing in either September or spring has been recommended. If seeds are to be sown shortly after collection, depulping is not essential, but seed cleaning and a water soak before planting may be beneficial (*Heit 1968*). Cleaned seed to be used in spring planting should be stratified in moist sand or peat for 120 to 160 days at 41°F (*Krefting and Roe 1949*) or for 60 to 90 days at 50°F (*Barton 1939*) before sowing. Seed may germinate in stratification if held too long. Stratified seed should be sown in the spring in drills at 25 seeds per linear foot, covered with ½ inch of

mulch until germination begins, and protected from birds and rodents (*U. S. Forest Service 1948*). The germination rates in one study were between 30 and 70 percent, with a 4:1 ratio between viable seed sown and usable seedlings produced (*Engstrom and Stoeckeler 1941*).

In the nursery, chokecherry is sometimes attacked by the fungus *Coccomyces lutescens* and the bacteria *Bacterium prunii*. Spraying with 4-6-50 or 3-4-50 bordeaux mixture or a 2-percent solution of lime sulfur will control the fungus (*U. S. Forest Service 1948*).

Field planting of various species of cherries is usually done with 1-0 stock on deep well-drained soil in sunny locations free of frost pockets (*U. S. Forest Service 1948*). Specific suggestions on field planting of chokecherry were not found, but this species grows better in partial shade than most other cherries.

MANAGEMENT

Chokecherry is a useful species for wildlife food and cover, erosion control, shelterbelts, and ornamentals. However, the usefulness of the species is impaired by its disease-hosting qualities and livestock-poisoning risk. The leaves are poisonous when wilted (*Harlow 1957*), and chokecherry should not be planted or maintained in pasturage (*Van Dersal 1938*). Its use as an ornamental may also be limited where risk of tent caterpillar infestation is high, but has been recommended for dry, shady locations (*Curtis and Wyman 1933, Kammerer 1934*).

PIN CHERRY

PIN CHERRY, *Prunus pensylvanica* L.f. Also called Bird Cherry, Cerises d'Ete, Fire Cherry, Northern Pin Cherry, Petit Merisier, Pigeon Cherry, and Wild Red Cherry.

By John R. Fulton

*Northeastern Forest Experiment Station
Morgantown, West Virginia*

RANGE

Pin cherry occurs from Newfoundland and southern Labrador to northern Ontario and west across Canada to British Columbia and south to the Rocky Mountains in Minnesota, Iowa, northern Illinois, northern Indiana, Pennsylvania, and New York and in mountains southward to Virginia, North Carolina, northern Georgia, and eastern Tennessee (Little 1953).

HABITAT

Pin cherry is a northern species; south of Pennsylvania it occurs only in the mountains. Throughout its range, the number of days of snow cover varies from 1 to 10 in the south to 120 days or more in the north, and the average growing seasons are 100 to 210 days (Van Dersal 1938). Average annual precipitation varies from 30 inches in Canada to 80 inches in the Great Smokey Mountains (U. S. Department of Agriculture 1941).

Pin cherry grows on many kinds of soil, from infertile sand to rich loam (Hosley 1938, Keeler 1915). Optimum soil pH is about 5.0 to 6.0 (Spurway 1941). In the north, pin cherry is found in nearly all forest types, usually in clearings, where it often forms thickets. In the

south it grows at elevations of about 2,500 to 4,500 feet (Core 1929, Stupka 1964). Pin cherry attains its largest size on western slopes of the Great Smokey Mountains in eastern Tennessee (Sargent 1949).

A shade-intolerant pioneer species, pin cherry often invades roadsides, old fields, burns, and similar openings. It often dominates these sites either in pure stands or with species such as aspen, red maple, black cherry, and white or gray birch (Society of American Foresters 1967). It is characteristic as a short-lived tree in hemlock, northern hardwoods, and spruce-fir forests (Core 1929, Shanks 1954). Pin cherry is a dominant natural revegetation species of coal-spoil banks in Pennsylvania (Bramble and Ashley 1955).

LIFE HISTORY

Pin cherry flowers from April to early June, when the leaves are half grown. The flower is perfect, white, $\frac{1}{2}$ inch across, and is born on a slender stalk in a four- or five-flowered group which usually is clustered with two or three other groups. The fruit is a red drupe, $\frac{1}{4}$ inch in diameter, and is thin-skinned and sour. Fruits ripen from July to August and may persist on the trees until October or later

(Keeler 1915, U. S. Forest Service 1948). Seed dispersal by birds and gravity occurs from July into the winter months (Keeler 1915, U. S. Forest Service 1948).

In a 4-year study in West Virginia involving pin cherries with an average dbh of 4.7 inches, the average fruit yield was 0.68 quarts per tree, half the trees bore fruit, and fruit yields varied substantially among years. The average fruit-ripening date was 31 August, and the latest date of fruit persistence was 6 October (Park 1942).

Pin cherry usually occurs as a tree 31 to 40 feet tall at maturity, but in the southern Appalachians specimens up to 91 feet tall and 5 feet 4 inches in circumference have been found (Stupka 1964). Pin cherry aggressively invades cleared areas and grows fast, particularly when young (Keeler 1915). Once established, it will reproduce by suckering and sometimes forms thickets on poor soils (Wright 1915). However, it is susceptible to several fungous diseases and parasitic insects, and has a shallow root system. Pin cherry seldom lives over 30 years and is usually replaced by shade-tolerant trees (Hosley 1938).

USE BY WILDLIFE

Pin cherry is an important wildlife food source. The fruit is eaten in summer and fall by at least 25 species of non-game birds, several upland game birds, fur and game mammals, and small mammals (Martin *et al* 1951). Pin cherry fruit constituted 4.5 percent of the fall diet of ruffed grouse in the Northeast (Edminster 1947). The buds are used by upland game birds, especially sharptailed and ruffed grouse. Foliage and twigs are browsed by deer (Martin *et al* 1951); however, a study showed the foliage to have an undesirably high calcium to phosphorus ratio for good deer nutrition (Bailey 1967). Pin cherry is also browsed by the cottontail rabbit (Sweetman 1944).

Pin cherry provides only fair nesting cover and materials for birds (Longenecker and Ellarson 1960), but this value would presumably be greater where pin cherries form dense thickets.

Beaver will cut pin cherry, sometimes completely removing small stands at the detriment of other wildlife.

PROPAGATION

The ripened fruits can be collected in late summer from trees or the ground. They should then be cleaned of pulp and can be sown early in the same fall, by planting 1 inch deep in mulched beds. Soaking the seeds in water before planting may be of benefit, but scarification is not necessary (Heit 1967c). If seeds are to be held over winter, they should be stratified in moist sand for 60 days at 68 to 86°F, then for 90 days at 41°F (U. S. Forest Service 1948). Seeds of pin cherry have retained viability for as long as 10 years when stored in sealed containers at 34 to 35°F (Heit 1967c).

The yield of cleaned seed was reported as 16 pounds per 100 pounds of fruit, and the number of cleaned seed per pound averaged 15,700 (U. S. Forest Service 1948). Seed may be available commercially from at least one source, but planting stock apparently is not sold (NE Regional Technical Center 1971).

Pin cherry is used as grafting stock because the wood unites readily with that of sour cherry (*P. cerasus*) (Wright 1915). Stocks are worked more commonly by budding than by grafting (Bailey 1950).

Little is known about field propagation of pin cherry, but recommendations for nursery practices may suggest field techniques. Once established, pin cherry usually maintains itself until it is overtaken by competing trees. It suckers readily and should grow well from root cuttings (Bailey 1950).

MANAGEMENT

Pin Cherry is a convenient species for use by wildlife managers who desire a fast-growing, aggressive, small tree that is widely utilized by game and other animals. It will provide quick cover on denuded land because it tolerates extreme soil conditions. Seeds of pin cherry have very hard coats and accumulate in the humus layer of the forest floor. They will germinate profusely when influenced by fire or lumbering operations (Hosley 1938).

Pin cherry will produce well under moderate to heavy deer browsing, and should be browsed at least moderately to keep plant growth within reach of deer (Aldous 1952).

But, most commonly, the wildlife values of pin cherry are obtained incidentally to its occurrence rather than through purposeful management. Despite its desirable qualities of wildlife use, soil-binding capability, and stock for commercial cherries, pin cherry is not widely cultivated.

Pin cherry is plagued by several diseases and parasites, which may spoil its appearance, at least. The most prominent leaf disease is cherry leaf spot, caused by the fungus *Coccomyces hiemalis*. This disease results in characteristic holes in the leaves and premature leaf fall. Repeated attacks reduce vigor of the tree. Another common disease is black knot, caused

by the fungus *Dibotryon morbosum*. This can be recognized by the numerous large black galls on the branches and twigs (Hepting 1971). The eastern tent caterpillar (*Malacosoma disstria*) sometimes completely defoliates cherries. Although pin cherries withstand repeated attacks of these insects, dead limbs, defects, and growth loss may occur (Kulman 1965).

Pin cherry has been controlled by spraying mixtures of 2,4-D and kerosene on foliage, stems, or stumps (Day 1948). Equal mixtures of 2,4-D and 2,4,5-T also have proved effective in killing seedlings and suckers (Egler 1949).

SWEET CRAB APPLE

Malus coronaria (L.) Mill.
(*Pyrus coronaria* L.)

Also called American Crabapple, Crabapple, Fragrant Crab, Garland-Tree, Narrow-Leaf Crab-Apple, Scented Crab, Wild Crab, Wild Crab Apple, and Wild Sweet Crab Apple.

By Robert W. Donohoe

Ohio Department of Natural Resources
New Marshfield

RANGE

Sweet crab apple does not occur naturally in the New England States or the Maritime Provinces. Range of the typical form is from central New York and southern Ontario to southern Wisconsin, south to Delaware, and in uplands to South Carolina, Tennessee, and Missouri. The variety *dasycalyx* is common in the western part of this area, particularly in Ohio and Indiana, and ranges to Minnesota and Kansas. Along the southern Appalachians, sweet crab apple occurs up to altitudes of 3,300 feet (*Fernald 1950, Little 1953, Sargent 1922*).

HABITAT

The range limits of sweet crab apple indicate that it is not adapted to the colder climates, northward or at high elevations, within the Northeast. Within its range limits, crab apple occupies a wide variety of soils and topographical situations (*Charles M. Nixon, personal communication concerning Ohio; Van Dersal 1938*). The tree does best in full sunlight on moist but well-drained, fairly heavy

soils (*Hough 1907, Van Dersal 1938*). The soil pH preferences are not documented, but may approximate those for prairie crab apple (*M. ioensis*): 6.0 to 6.5 for nursery soils and 5.5 to 8.0 for field soils (*Wilde 1946*). Although sweet crab apple does best on moist, rich soils, it will tolerate drier soils of moderate fertility (*Edminster 1947, Van Dersal 1938*).

Sweet crab apple is often found in forest glades among taller trees (*Hough 1907*). In Ohio it is associated with old-field succession and commonly occurs with hawthorn, elm, ash, hickory, and sumac (*Charles M. Nixon, personal communication*). In southeastern Ohio, sweet crab apple on slopes of northern exposure is associated with pawpaw, flowering dogwood, hawthorn, American hophornbeam, sourwood, pin cherry, and sassafras; on ridges with serviceberry, pawpaw, flowering dogwood, common apple, and sassafras; and on flood plains with pawpaw, spicebush, wahoo, wild plum, and elderberry (*Hart 1951*).

A survey of spoil resulting from strip-mining for limestone in northeastern Ohio (Stark County) revealed good natural plant invasion and establishment after 21 years. Sweet crab

apple had become established along with white ash, black cherry, American elm, red elm, cottonwood, sassafras, hawthorn, and red-osier dogwood (Riley 1952).

LIFE HISTORY

The flowers of sweet crab apple appear in March to May and are white and flushed pink. The fruits ripen in late summer or early fall, are yellow-green in color, and are 1 to 1¼ inches in diameter (U. S. Forest Service 1948, Van Dersal 1938). Leaf color in the fall is yellow, and nearly all leaves are off by November 1.

In Michigan an 8-year study of fruit production by 13 species of plants that may be used by wildlife showed that crab apple had the largest mean weight (103 g, range 1.2 to 162.9 g) per square foot of crown surface (Gysel and Lemmien 1964). In another Michigan study, sweet crab apple was considered to be a heavy and consistent fruit producer. The fruits ripened by October; nearly all had fallen by December 1, but some persisted until January 1. Fruits softened after falling and were badly discolored by December 1 (Hosley 1938). A fruit-production survey on sweet crab apple in southern Ohio (Scioto County) for three successive years revealed that out of a sample of 100+ trees, 40 percent produced fruit in 1935, 10 percent produced fruit in 1936, and 50 percent produced fruit in 1937 (Chapman 1938).

The fruit of sweet crab apple contains 4 to 10 small- to medium-size dark seeds. Heavy seed crops are produced every 2 to 4 years, and medium to light crops in intervening years. One pound of cleaned seed can be obtained from 100 pounds of fruit (Swingle 1939). The average number of cleaned seed per pound was reported as 14,000, but may be as much as 70,000 (Edminster 1947, Isely 1965). In nature, the seed is disseminated by gravity and animals (U. S. Forest Service 1948).

Sweet crab apple reproduces primarily from seed. The tree attains the height of 25 to 30 feet, has a trunk rarely more than 12 to 14 inches in diameter, and when isolated develops a broad top, 20 to 25 feet in diameter, with rigid branches bearing many short branchlets

terminating in sharp spur-like leafless tips (Hough 1907).

The sweet crab apple is not shade-tolerant. It is part of the old-field succession and often forms dense spiny thickets when it does not have competition from overstory trees. It is sometimes found growing in the forest under-story; however, in this situation, growth is poor and fruit production is minimal.

USE BY WILDLIFE

The apples include about 25 species, many of which are of value to wildlife, and one of the chief uses of sweet crab apple is for wildlife food (U. S. Forest Service 1948).

Data about use of sweet crab apple are scanty. But the following information about all apple species collectively seems to apply reasonably well to sweet crab apple. Ruffed grouse, ring-necked pheasant, and bobwhite quail eat the fruit, seeds, and buds of apple. The purple finch, grackle, blue jay, baltimore oriole, orchard oriole, robin, yellow-bellied sapsucker, starling, tufted titmouse, rufous-sided towhee, cedar waxwing, and the downy, hairy, red-bellied, and red-headed woodpeckers eat the fruits and seeds. The fruit and bark of the apple are eaten by the black bear, gray and red fox, opossum, porcupine, cottontail rabbit, raccoon, eastern skunk, fox squirrel, deer and pine mouse, and Allegheny wood rat. The twigs and foliage are browsed by white-tailed deer (Martin et al 1951).

A food-habit study of white-tailed deer in Ohio showed that fruit of the sweet crab apple ranked first in the diet of animals from the eastern part of the state (Nixon and McClain 1966).

Sweet crab apple provides excellent cover for many wildlife species, especially where it forms dense spiny thickets in old fields.

PROPAGATION

Ripe crab apples can be picked from the trees or gathered from the ground in September or later. A bushel of fruit yields 2 to 3 pounds of cleaned seed; and, as a rule of thumb, a pound of cleaned seed may produce about 2,000 usable seedlings (Edminster 1947).

Seeds can be extracted by macerating the fruit in water and floating off or screening the pulp. The wet seed mass can be fermented, in a waterbath with yeast added, but must not remain in the bath longer than 48 hours (*Edminster 1947*). Cleaned seed should then be dried, and, if necessary, can be stored in sealed containers, at temperatures just above freezing. Apple seeds (*M. pumila*) stored in this way retained viability for at least 2½ years (*U. S. Forest Service 1948*).

Seeds can be stratified in moist sand or peat at 41°F for 60 to 120 days. The longest period, 120 days, hastened subsequent germination (within 24 days), whereas the germination time was longer (within 104 days) following 60-day stratification. In other words, total time to germination was about 21 weeks with 120-day stratification and over 23 weeks with 60-day stratification (*U. S. Forest Service 1948*).

Fresh seeds can be sown in the fall, at the rate of 1 pound of seed per 100 square feet of soil, and then covered with ¼ inch of soil plus mulch (*Edminster 1948*). Seeds of a closely related species (*M. ioensis*), collected when slightly green and sown immediately, germinated 100 percent the following spring. Alternatively, stratified seed can be sown in the spring, preferably in drills (*U. S. Forest Service 1948*).

Optimum planting density in the nursery is about 10 plants per square foot. Seedlings are ready for outplanting when about 6 inches tall by 3/16 inch diameter above the root collar, as 1-0 or 2-0 stock (*Edminster 1947*).

Sweet crab apples can be outplanted in a variety of soils and site conditions. They do best when grown in a moderate temperate climate on a clay-loam soil (*U. S. Forest Service 1948*). Fallow fields, fields in the early successional stages, and forest openings are places where sweet crab apple can be established.

Flowering crab apple (*Malus* sp.), at least, can also be propagated by whip grafting onto apple seedling roots in January or February. The stocks are dug in the fall and stored until used. Six- or 8-inch scions should be used on about 3-inch root pieces. The unions are tied with waxed string, and the grafts are stored overwinter like hardwood cuttings, or set singly in boxes of moist peat and lined out in a similar way in the spring. If set deep in the soil, many of them develop their own roots (*Laurie and Chadwick 1931*).

MANAGEMENT

Sweet crab apple in old fields can be managed by preventing the invasion of overstory species. Cutting, girdling, or using herbicides on invading trees, which would eventually cause shade, may be the best management technique.

Sweet crab apple may be controlled in part by using herbicides equivalent to 2,4-D, or 2,4-D and 2,4,5-T (equal parts of each). When used at the rate of 3,000 parts per million, diluted in water and applied to foliage, these herbicides gave good control on young seedlings, but only fair control on older trees (*Rudolf and Wait 1956*).

MISCELLANY

The wood of sweet crab apple is heavy, close-grained, not strong, light red, with yellow sapwood of 18 to 20 layers of annual growth. It is used for levers, tool handles, and many small domestic articles. The tree is sometimes planted in gardens in northern and eastern states (*Sargent 1922*).

The fruit of sweet crab apple makes a delicious marmalade or jelly (*Fernald and Kinsey 1943*), or cider and vinegar (*Isely 1965*).

Crab apples are susceptible to air-pollution damage from HCl, Cl₂ and ozone (*Sucoff and Bailey 1971*).

DOGWOODS

FLOWERING DOGWOOD, *Cornus florida* L. Also called Arrowwood, Boxwood, Cornelius-Tree, Dogwood, False Box, Florida Dogwood, Nature's Mistake, White Cornel.

ALTERNATE-LEAF DOGWOOD, *Cornus alternifolia* L.F. Also called Blue Dogwood, Gray Dogwood, Green Osier, Osier, Pagoda Dogwood, Red Osier.

ROUNDLEAF DOGWOOD, *Cornus rugosa* Lam. Also called Bois de Calumet.

SILKY DOGWOOD, *Cornus amomum* Mill. Also called Kinnikinnik, Red Willow, Silky Cornel, Squawbush.

By Walter A. Lesser
Department of Natural Resources
Elkins, West Virginia

and

Jean D. Wistendahl
Ohio University
Athens

RANGE

The four species of dogwood discussed here are found in most of the Northeast, but two are rare or absent in Canada.

Flowering dogwood ranges north from Florida and Texas to southwestern Maine and southern New Hampshire and Vermont, west to southern Ontario and Michigan and south to Missouri and Kansas (*Little 1953*).

Alternate-leaf dogwood ranges farther north, into New Brunswick and Nova Scotia and westward along the St. Lawrence valley to the northern shores of Lake Superior and to eastern Minnesota. The southern limits are eastern Kentucky, Ohio, West Virginia, Maryland, Delaware, and New Jersey (*Sargent 1922*).

Silky dogwood ranges from southern Maine to southern Illinois and Indiana south to South Carolina and Alabama (*Gleason and*

Cronquist 1963). Roundleaf dogwood, a more northern species, is found from Quebec to northern Ontario, south to New Jersey, Pennsylvania, northern Ohio to northeastern Iowa, and in the mountains to Virginia (*Gleason and Cronquist 1963*).

HABITAT

These dogwoods are found either as understory species in many forest types or as thicket-forming shrubs of fields and wet areas. Within the ranges of these four dogwoods, annual precipitation varies from a low of 30 inches per year in the north to a high of 80 inches in Florida, where there is no snowfall, to more than 50 inches of snow in the north. Temperature extremes are from -30° to 115° F (*Fowells 1965*). The growing season ranges from 160 days in southern Michigan to 300 or more days in Florida (*Fowells 1965*).

Dogwoods tolerate a wide variety of climatic conditions, but roundleaf dogwood does not range beyond the southern reaches of the Northeast except in the mountains to Virginia (Gleason and Cronquist 1963).

Flowering dogwood is one of the most adaptable and widely distributed understory trees of the eastern deciduous forests—growing in a variety of soils from well-drained uplands to the deep, moist soils of streambanks (Fowells 1965). It is commonly found on soils having pH values of 5 to 7 (Spurway 1941); and optimum growth occurs in moist fertile loam that is slightly acid (Fowells 1965). In cut-over loblolly pine stands on the Virginia coastal plain, flowering dogwood was most common on soils having good drainage and light texture; it was almost absent on poorly-drained, heavy soils (Wenger 1956).

Alternate-leaf dogwood grows in rich woodlands, along the margins of forests and along streams in moist well-drained soils (Ammons 1950, Sargent 1922) as well as in dry woods and on rocky slopes (Fernald 1950). Silky dogwoods occurs in more moist situations, especially along streams (Ammons 1950, Gleason and Cronquist 1963) and in swamps and thickets (Fernald 1950). Roundleaf dogwood occurs mostly in dry woodlands and on rocky slopes (Fernald 1950).

Although flowering dogwood is most prominent in two forest types, scarlet oak and white oak-red oak-hickory, it is found in many hard wood and conifer types (Fowells 1965). In the scarlet oak type, dogwood associates are: scarlet, southern red, chestnut, white, and post oaks; hickories; blackgum; sweet gum; black locust; and pitch, shortleaf, and Virginia pines. In the white oak-red oak-hickory type, flowering dogwood is associated with yellow-poplar; pignut, shagbark, and mockernut hickories; white ash; red maple; beech; and blackgum (Fowells 1965).

The following species are associated with flowering dogwood in the moist, climax forest understory: magnolias (*Magnolia tripetala*, *M. macrophylla*, and *M. fraseri*), sourwood, striped maple, redbud, American hornbeam, eastern hophornbeam, American holly, and downy serviceberry (Braun 1950). In the hill section of Indiana, flowering dogwood is con-

spicuous in the understory. It is a dominant understory species in the white oak forests of the Shenandoah Valley (Braun 1950).

Alternate-leaf dogwood is among the shrubs that are generally abundant in moist woods, along with spicebush, witch-hazel, pawpaw, and wild hydrangea (*Hydrangea arborescens*) (Braun 1950). In oak forests at moderate elevations, the understory may include alternate-leaf dogwood, witch-hazel, mountain-camellia (*Stewartia ovata*), mountain winterberry, and Virginia creeper. Rhododendron and mountain-laurel may be present, particularly if eastern hemlock is in the canopy (Braun 1950). In the sugar maple-white elm areas in Alger County, Michigan, alternate-leaf dogwood, prickly gooseberry (*Ribes cynosbati*), and virgin's-bower (*Clematis virginiana*) are widely distributed along with more northern species such as American yew, mountain maple, red-berried elder, beaked hazel, and American fly honeysuckle (Braun 1950). In Colebrook, Connecticut, alternate-leaf dogwood along with witch-hazel, mapleleaf viburnum, and American fly honeysuckle are frequently found in mature forests (Braun 1950).

In the sugar maple-basswood forests of the Midwest, roundleaf dogwood and bush-honeysuckle (*Diervilla lonicera*) are the northern species of shrubs indicative of the transitional nature of this zone (Braun 1950). In the mixed forest of the hemlock-white pine-northern hardwoods region, there are a large number of shrubs and small trees including roundleaf dogwood, alternate-leaf dogwood, mountain maple, serviceberry, eastern hophornbeam, American mountain-ash, gooseberries (*Ribes* spp), beaked hazel, rope-bark (*Dirca palustris*), bush-honeysuckle, American fly honeysuckle, and thimbleberry (*Rubus parviflorus*) (Braun 1950).

In a study of old fields on the floodplain of the Raritan River in New Jersey, silky dogwood was found in association with blackberries, poison ivy, shining sumac, smooth sumac, blackhaw viburnum, southern arrow-wood, Carolina rose, bayberry (*Myrica pensylvanica*), gray dogwood, and grape (*Wistendahl 1958*).

LIFE HISTORY

The flowers of flowering dogwood are greenish white to creamy, perfect, in heads surrounded by four showy, petal-like, white, deciduous bracts (pink in the form *rubra*) (Preston 1966). The flowers open at the same time the leaves expand—in March at the southern end of the range to June in northern areas (U. S. Forest Service 1948). The light cream-colored flowers of alternate-leaf dogwood are in broad flat open clusters that open from May in the south to June in the north (Ammons 1950). Flowers of the two other species are white, in flat clusters, and appear from May to July (Ammons 1950).

Fruiting time varies with species and location. Flowering dogwood has ovoid scarlet fruits $\frac{1}{2}$ inch long and $\frac{1}{4}$ inch wide with thin, mealy flesh (Fowells 1965). The fruits ripen from September to late October (U. S. Forest Service 1948). Alternate-leaf dogwood has a dark blue, globe-shaped fruit about $\frac{1}{3}$ inch in diameter when it ripens in September (Ammons 1950). The fruit clusters are loose, spreading, and red-stemmed (Brush 1957). The pale blue fruits of silky dogwood are also in loose clusters and ripen in September (Ammons 1950). Fruits of roundleaf dogwood are light blue and sphere-shaped; they ripen from August to October (Ammons 1950, Fernald 1950).

Flowering dogwood bears good seed crops about every other year, but seeds from isolated trees are frequently hollow (U. S. Forest Service 1948). Both wild and nursery-grown flowering dogwoods fruited for the first time at 6 years of age (Spinner and Ostrom 1945). Seed is dispersed in October to late November or later, by gravity, birds, and other animals (U. S. Forest Service 1948). The number of seeds per ounce averaged 280, with a range from 200 to 390 (U. S. Department of Agriculture 1961a). The yield of seed per 100 pounds of fruit ranged from 22 to 46 pounds, and the average number of cleaned seed per pound was 4,500 (U. S. Forest Service 1948).

In a yield and fruit-persistence study of flowering dogwood in West Virginia for a 4-year period, 71 percent of the plants produced fruit, average date of ripening was September 20, and the latest date of fruit persistence on

the plants was December 2. The plants exhibited a crop failure in 1 of the 4 years (Park 1942). In Texas, 88 percent or more of trees $3\frac{1}{2}$ inches dbh and larger fruited each year. Year-to-year differences were more pronounced in the smaller diameter classes. The fruit ripened in September and some persisted on trees until January. Average fruit production was 37.9 pounds per square foot of basal area (Lay 1961). Flowering dogwood yields fruit under a heavy overhead canopy even in a poor seed year if the site is fair to good (Crawford 1967).

Alternate-leaf dogwood yields of cleaned seed ranged from 5,900 to 9,500 and averaged 8,000 seeds per pound (U. S. Forest Service 1948, Vines 1960). Seed is dispersed from July through September (U. S. Forest Service 1948).

Silky dogwood seeds are dispersed from September to mid-October. Seed yields were 17 pounds of cleaned seed per 100 pounds of fruit and 10,900 to 11,600 cleaned seeds per pound (U. S. Forest Service 1948). In southwest Michigan, fruits remained on the shrubs for about 90 days after ripening (Gysel and Lemmien 1955). The average germination of silky dogwood was reported to be 10 percent (Forbes 1955). Annual fruit production for an 8-year period on the Kellogg Forest in Michigan ranged from 0.7 g per square foot of crown surface to 46.6 g and averaged 17.9 g (Gysel and Lemmien 1964).

No information was found on seed production of roundleaf dogwood. This species occurs only infrequently throughout its range (Ammons 1950).

Natural germination of dogwood seed occurs in the spring after the seed has fallen and lain on the ground over winter. All species of dogwood show delayed germination due to embryo dormancy and, in some species, to impermeability or hardness of the seed coat (U. S. Forest Service 1948). The best natural seedbeds are moist, well-drained, rich loams (Vimmerstedt 1957).

Flowering dogwood seedlings usually show rapid root growth. Height growth is relatively fast during the first 20 to 30 years but then practically ceases, although individual plants may live 125 years (Fowells 1965). Flowering

dogwood has a long growing season. In a Massachusetts nursery, flowering dogwood displayed a height growth pattern different from that of any other species studied. The dogwoods grew from 24 April to 4 September, and 90 percent of growth occurred during 95 days from 15 May to 18 August. The most rapid growth occurred during the first week in August, then growth suddenly slowed down.

This species has been reported to grow nearly all summer, but to stop temporarily during periods of adverse conditions (*Kozlowski and Ward 1957*). In the Georgia Piedmont, the most rapid radial growth of stems occurred during an 80- to 89-day period. Half of the total radial growth was completed in 40 to 49 days (*Jackson 1952*).

Soil moisture was the most important factor determining survival of 1-year-old flowering dogwood seedlings in the North Carolina Piedmont (*Ferrell 1953*). In another North Carolina Piedmont study, flowering dogwood seeds were planted in three situations: in an open field, under pine stands, and on the margins of pine stands. Survival was significantly higher on the margins of pine stands than on the other two sites, but there was no significant difference in survival between the open field and the pine forest. The intermediate light intensity of the margins provided some advantage that compensated for a reduced water supply. However, dogwood growth was greater in the open than in the margin or the pine forest. Seedlings in the forest were the smallest (*Kramer et al 1952*).

Flowering dogwood reproduces by sprouting, and it sprouts most profusely when cut in late winter (*Buell 1940*). It also reproduces extensively by layering (*Spector 1956*, *U. S. Forest Service 1948*, *Vines 1960*).

Maximum height for flowering dogwood on good sites is about 40 feet, with a dbh of 12 to 18 inches, attained in 20 to 30 years (*Fowells 1965*). Near the northern limits of its range, flowering dogwood becomes a many-branched shrub (*Vimmerstedt 1957*). Alternate-leaf dogwood, under favorable conditions, becomes a small tree not more than 30 feet in height, with a short trunk 6 to 8 inches in diameter (*Sargent 1922*). Silky dogwood, with its upright to spreading form, grows to a height of 3

to 10 feet (*Vines 1960*). Roundleaf dogwood is a shrub reaching 6 to 10 feet (*Ammons 1950*).

Flowering dogwood is well adapted as an understory tree. It has the ability to carry on maximum photosynthesis at one-third of full sunlight, which helps explain how it survives and grows under a forest canopy (*Fowells 1965*). Flowering dogwood is comparable in shade tolerance to white oak (*Vimmerstedt 1957*).

Because flowering dogwood has thin bark, it is readily injured by fire. In the Northeast, fires killed the above-ground parts of all the flowering dogwoods on a study area after 1 year (*Stickel 1935*). Fire-damaged trees, however, have ability to sprout profusely (*Vimmerstedt 1957*). Once trees reach 10 to 15 feet in height they can withstand infrequent winter burns of low intensity (*Halls and Oefinger 1969*).

Flooding is also detrimental to flowering dogwood. In one experiment, flooding killed all potted seedlings in 1 to 3 weeks (*Parker 1950*). Flowering dogwood is also susceptible to drought, although it can tolerate low and high temperatures. In prolonged periods of drought, the leaves often turn red and curl, and severe dieback of the top may result (*Vimmerstedt 1957*).

USE BY WILDLIFE

The dogwoods are extremely valuable for wildlife. The seed, fruit, buds, flowers, twigs, bark, and leaves are utilized as food by various animals.

As a wildlife food, the most distinguishing quality of flowering dogwood is its high calcium content. Samples collected in southern pine-hardwood forests contained 1.72 percent calcium in leaves, 1.44 percent in twigs, and 0.89 percent in fruits. These amounts are well above those needed by wildlife for good skeletal growth (*Halls and Oefinger 1969*). Compared with other fruits, flowering dogwood is outstanding for its content of calcium and fat. Fruit collected in Texas had the following percentage composition: protein 5.49, fat 16.17, fiber 24.64, ash 4.96, phosphorus 0.6, and calcium 1.10. Leaves and twigs contained 1.75 to 2.90 percent calcium (*Lay 1961*).

Alternate-leaf dogwood was deficient in

phosphorus, as were 11 of the 20 plant species analyzed in a study of the mineral content of deer browse on the Huntington Wildlife Forest in New York (Bailey 1967).

Flowering dogwood has been recorded as food taken by at least 36 species of birds, including ruffed grouse, bob-white quail, and wild turkey. Records of mammals eating this dogwood include eastern chipmunk, white-footed mouse, gray fox, skunk, cottontail rabbit, white-tailed deer, beaver, and gray squirrel (Chapman 1947a, Van Dersal 1938, Vines 1960). In the Missouri Ozarks, flowering dogwood contributed as much or more than any other soft-fruited species to the diet of wild turkeys, and was prominent in the diet of turkeys from fruit ripening in September until February (Dalke et al 1942). Dogwood fruit was in 10 percent of 115 crops from wild turkeys collected on the George Washington National Forest during three falls and early winters. Dogwood was fourth in importance among all foods (Martin et al 1939). Flowering dogwood ranked 21st on a list of quail food plants of the Southeast, and was listed as a preferred food of the wild turkey (Vines 1960). In east Texas, fruit of flowering dogwood was found in 16 percent of 49 deer stomachs collected in November and December. Fruit remains were also found in deer pellet groups (Lay 1965a). In a study of cottontail rabbits in southwest Michigan, flowering dogwood rated second among 18 winter food plants (Haugen 1942). In Massachusetts, winter food choices among 100 species of woody plants were analyzed for relative attractiveness as food of the cottontail rabbit. Browsing by rabbits severely injured the flowering dogwood but injured alternate-leaf dogwood only slightly (Sweetman 1944).

Fruits of alternate-leaf dogwood have been reported eaten by at least 11 species of birds, including ruffed grouse. Black bears may be especially fond of this fruit (Chapman 1947a). Leaves and stems are eaten by white-tailed deer and cottontail rabbits (Van Dersal 1938, Vines 1960).

Silky dogwood fruit is utilized by at least 10 species of birds (including ruffed grouse, bob-white quail, wild turkey, and ring-necked pheasant), and cottontail rabbit, woodchuck,

raccoon, and squirrels. Cottontails eat the fruit and browse the stems (Holweg 1964, Van Dersal 1938). In West Virginia, wood ducks readily eat silky dogwood fruits in late summer and fall, before and after ripening. Wood ducks have been seen reaching as far as they can from the water to strip the shrubs of fruit.

Roundleaf dogwood fruit has been found in stomachs of ruffed grouse and sharp-tailed grouse, and feeding observations have been made of the blue-headed vireo, cottontail, and moose (Van Dersal 1938). A ruffed grouse from Delaware County, New York, had eaten 226 roundleaf dogwood fruits on December 20 (Bump et al 1947).

All species of dogwoods possess cover value, but that of roundleaf is least due to its infrequent occurrence (Korschgen 1960, McAtee 1936). Animals trapped or observed in plantings of silky dogwood on the Kellogg Forest in Michigan included short-tailed shrew, striped ground squirrel, red squirrel, white-footed mouse, meadow vole, and meadow jumping mouse (Gysel and Lemmien 1955). A study of power line right-of-way vegetation and animal use in southern Michigan revealed that the silky dogwood-willow shrub community was used by cottontails, raccoon, red squirrels, and opossums (Gysel 1962). In West Virginia, silky dogwood on streambanks provides brood and escape cover for wood ducks. The thick- et-forming silky dogwood also provides cover for woodcock.

PROPAGATION

Because these dogwoods, except roundleaf, are highly prized for ornamental purposes, seed (dried fruit or cleaned stones) and planting stock are available from commercial growers. Dogwoods can be grown from root cuttings, layering, and by division, as well as from seed (Fowells 1965). If seed is to be collected, isolated plants should be avoided because they often have a high percentage of empty stones, in flowering dogwood at least (U. S. Forest Service 1948).

Because the fruit pulp contains an unknown chemical that delays germination (Goodwin 1948), cleaned seeds are preferable for germination in the nursery. The pulp may be removed by soaking fruit in water for a few days

until the covering is soft and easy to remove (Free 1957). Large quantities of fruit may be macerated in water or run through a hammer mill, allowing pulp and empty stones to wash away (U. S. Forest Service 1948). Dogwood seed should then be dried and stored in an airtight container at 34 to 38° F.

Stratification is necessary to break seed dormancy. The seed can be stratified in moist sand or peat moss for four months at 33 to 41° F. Seed can be sown in drills or broadcast and covered with ¼ to ½ inch of nursery soil depending on the size of the seed. Forty of the smaller seeds are sown per square foot and mulched with leaves or straw. The mulch is removed as soon as germination begins (U. S. Forest Service 1948).

In nurseries where small lots of seeds are used, broadcast sowing is recommended; and for fall sowings, heavy mulch is needed for winter protection. A heavy mulch prevents solid freezing of seeds during an open winter and may induce much higher germination the following spring (Heit 1968). For seeding in the fall, seeds should be gathered just as they go into the meaty stage, but before the outside coat becomes hardened or impervious to moisture and air.

In one test, seeds of alternate-leaf dogwood gathered and planted on 8 July attained a germination of 100 percent the following spring. Roundleaf dogwood seed gathered and planted on 2 September also had a germination of 100 percent the following spring (Titus 1940). But seeds of alternate-leaf and roundleaf dogwoods usually are extremely dormant and probably should be sown in July or early August or stored, stratified, and sowed in the spring as previously described. Silky and flowering dogwood seed are less dormant and may be fall-seeded in September or October (Heit 1968). One author reported greater success with spring seeding than fall seeding and used builder's sand as the stratification medium (Miller 1959). Nursery germination of flowering dogwood seed may range from about 77 percent to 85 percent (U. S. Forest Service 1948).

The number of usable plants (1-0 or 2-0 stock) per pound of clean seed was 200 for flowering dogwood and 1,400 for silky dogwood (Bump et al 1947).

Dogwoods are reproduced vegetatively by various means: softwood cuttings in summer, hardwood cuttings in winter, grafting in winter or spring, layering in spring and summer, from suckers and divisions in spring, and budding in the summer (Mahlstede and Haber 1957). Vegetative reproduction is necessary to propagate plants for characteristics such as color of flowers and fruit retention.

Flowering dogwood roots readily from cuttings taken in June or immediately after the plants bloom. The advantages of taking cuttings early in the season are that they obtain maximum growth and harden off before the first winter. Only terminal shoot tips should be used, trimmed to 3 inches in length and leaving two to four leaves (Pease 1953). One author claimed that rooting was faster when four leaves were retained rather than two (Doran 1957). Dogwood cutting results were better when a medium of sand or sandy soil was used rather than peat moss (Doran 1957, Pease 1953, Vermeulen 1959). The cutting bases should be dipped in a mixture of indolebutyric acid crystals and talc, one part acid crystals to 250 parts talc by weight. Cuttings are then set 1-1/4 inches deep in the rooting medium. The cuttings should be removed in early August and placed in a cold frame in light, well-drained soil with a pH of about 5.0 (Pease 1953). Cuttings from young trees usually show better growth after rooting than do cuttings from mature trees; also the survival of rooted cuttings from old trees may be poor (Doran 1957, Pease 1953). In addition to the indolebutyric acid treatment, one author reported that wounding the cuttings provided a better distributed root system (Bridgers 1955).

The red form of flowering dogwood (*C. f. rubra*) is difficult to start from cuttings and is usually propagated by budding in late summer or whip-grafting in winter on flowering dogwood seedlings (Hartmann and Kester 1968).

Dogwoods can be propagated successfully by grafting during the winter or early spring months. Scions may be collected in advance of the grafting work, and stored for 3 or 4 weeks in plastic containers with a small amount of sphagnum moss to prevent drying. Scions should be restricted to wood of the previous growing season. Wood to be used as scions

should be about the diameter of a lead pencil, 8 to 12 inches long, and should contain three or 4 sets of buds (Coggeshall 1960). Grafting techniques most commonly used include the whip-and-tongue method, side graft, and bench or bare-root graft (Coggeshall 1960, Wells 1955). A disadvantage in the whip-and-tongue method is the total loss of the seedling rootstock in the event of graft failure. This does not occur when a side graft is used (Coggeshall 1960).

Some dogwood graft failures have been attributed to a black mold fungus appearing as a crumbly, crust-like black layer on cut surfaces of both the rootstock and scion. The mold prevents callus formation. Growers have reported losses as high as 60 to 70 percent of their grafts. Control of this fungus is through sanitation and use of healthy vigorous stock (Collins 1960).

Dogwoods are budded in late July or early August, using 1-year-old seedlings in the field. The shield or T-bud method is normally used, placing the bud as low as possible and on the southwest side of the seedling. This results in a straight plant. The following spring, before the bud starts growth, the tops of the seedlings are removed by cutting just above the new bud union (Shadow 1959).

Layering is a satisfactory method of propagating dogwoods. Plants produced by layering soft, growing shoots are often superior to those raised from hardwood cuttings. Layering is done by starting against the base of the stock plant and working out, layering the shortest shoots first. A slight twist is all that is needed, but small pegs should be used to keep the layers firm. The layers are lifted the following spring and lined out 1 foot apart (Sheat 1953).

Division of dogwoods is carried out just before spring growth. Plants are lifted, pulled apart with small divisions, and lined out about 10 inches apart (Sheat 1953).

Transplanting flowering dogwoods with a root ball is preferred over bare-root transplanting, although both methods can be successful. Plants entering their third year are well suited for planting in permanent locations. Plants of this age are usually 2 to 3 feet tall and can be dug easily without excessive disturbance to the root system, thereby insur-

ing unchecked growth after transplanting. The transplants may be fertilized with a mixture of cottonseed meal and superphosphate in early spring at the rate of 5 to 7 trowels-full per plant (Miller 1959). Alternate-leaf dogwoods are easily transplanted with bare roots when the shrubs are less than 3 feet in height (Brush 1957). Dogwoods should be transplanted only in the spring (De Vos 1953, Wis-ter 1950).

MANAGEMENT

Although flowering dogwood fulfills requirements of many wildlife species for food and cover, it is seldom planted for this purpose, but may be a practical means of improving wildlife habitat where fruit-producing hardwoods are scarce (Halls and Oefinger 1969). Flowering dogwood has been suggested for planting along streams, at the edge of farm woodlots, and around farm ponds (Chapman 1947a). It certainly commands attention in the management of understory plants for forest game habitat.

Silky dogwood was highly regarded by game managers for use in ruffed grouse management in southern Michigan (Zorb 1966). This shrub has been especially useful for streambank stabilization when planted in combination with grasses (Porter and Silberberger 1960). Silky dogwood has also been used successfully in strip-mine reclamation (Bramble 1952, Hart and Byrnes 1960).

Field plantings of flowering dogwood in the Northeast have not been especially successful. Survival in 22 plantings after 5 to 12 years ranged from poor to excellent, being satisfactory in only 13 plantings. Most plantings had grown only about 3 feet in 5 to 8 years. None had reached site domination or a complete canopy. Retarding factors seemed mainly to be poor soil and herbaceous plant competition (Edminster and May 1951).

In a study of flowering dogwood survival in the North Carolina Piedmont, improvement of forest soil moisture conditions was considered the most important initial step in securing satisfactory reproduction. Soil moisture conditions may be improved by the use of a heavy harrow or disk plow to break up the surface

organic matter and cut out some of the competing roots. This should be a good method for use in a good seed year, but an immediate cutting of the overstory is not desired. The result from exposing mineral soil should be a satisfactory stand of dogwood reproduction even under a fairly dense canopy. Releasing this reproduction at a later date would be important (Ferrell 1953).

Flowering dogwood may be reproduced from stump sprouts by cutting trees in late winter. Tallest dogwood sprouts have been produced by cutting in March. For discouraging dogwood sprouting, midsummer cutting is recommended (Buell 1940).

Of 59 silky dogwood plantings in the Northeast, 37 had excellent and 19 had good survival. The few failures were attributed to excessive grass competition or infertile soil. Survival was about the same from Vermont to West Virginia. After 12 or 13 years, plantings had reached heights of 8 to 12 feet on better soils but only 5 to 6 feet on some poorly drained, acid soils in New York (Edminster and May 1951). When 20-year-old plantings were checked in New York State, silky dogwood was found to have grown vigorously and dominated all the sites (Smith 1962). Survival of silky dogwood on strip-mine spoilbank plantings has ranged from 45 to 72 percent, and it is a promising species for spoilbank reclamation (Bramble 1952, Bramble and Ashley 1949, Hart and Byrnes 1960).

When silky dogwood is to be planted, 1- or 2-year-old nursery-grown seedlings are recommended. The top growth of nursery stock should be pruned back to a height of 3 to 6 inches just before planting. Like most hardwood shrubs, competition from other plants retards early growth. Hence, plantings should be made in plowed furrows or scalped sod areas. For complete site dominance, silky dogwood seedlings should be spaced 3 to 4 feet apart (Edminster and May 1951).

Use of inorganic nitrogen fertilizer has stimulated radial growth of dogwoods of various ages on soils of low to moderately low fertility. Nitrogen was applied as ammonium nitrate, 32 1/2 percent, at various rates. Marked growth response occurred the first growing season after fertilization. The response was

less favorable the second year and insignificant the third year. A nitrogen application of 500 pounds per acre resulted in almost maximum growth response (Curlin 1962).

The quality of flowering dogwood browse has been improved by controlled burning, especially burning in the spring rather than in fall or winter. Summer burning probably would be as good as spring burning. Burning increased the protein and phosphoric acid content of browse (Lay 1957).

Diseases and parasites that attack the dogwoods include noninfectious diseases resulting from an unfavorable environment, parasitic diseases, nematodes, and insects. Noninfectious diseases include sun scald, mechanical and drought injury, freezing, and improper soil nutrient balance (Beecher et al 1964). Diseases and insects may kill dogwoods, but in most cases are only detrimental to the health and vigor of the trees.

The common diseases of flowering dogwood include spot anthracnose caused by the fungus *Elsinoe corni* and *Septoria* leaf spot. The spot anthracnose fungus attacks leaves, bracts, stems, and ripe fruits and affects mostly the lower crown. The symptoms are spots about 1 mm in diameter on the blooms and leaves. Centers of the small spots fall out, giving a shot-hole appearance to the leaves. The appearance of the blooms may be seriously affected. If the disease is not controlled, it may become so severe that flower buds never open (Beecher et al 1964, Cleveland 1951). This infection can be controlled by spraying four times per year with either captan 50 percent wettable powder, 1 1/2 tablespoons per gallon of water; maneb 80 percent wettable powder per gallon of water; or folpet 75 percent wettable powder at the rate of 2 tablespoons per gallon of water. The first application is made in early spring when the flower buds are beginning to open. The second spray is applied as soon as the bracts have fallen, the third spray 4 weeks later, and the fourth in late summer after the new flower buds are well formed (Beecher et al 1964).

Septoria leaf spot appears on flowering dogwood about mid-June in Virginia. It is caused by the fungus *Septoria cornicola*, which overwinters on leaves, either on the ground or on

leaves remaining attached to the tree. The symptoms are numerous small angular spots bordered by veins. The spots are purple at first, then become paler in the center, but rarely drop out. The spots may also blacken and roughen the fruit. Control consists of spraying with water solutions of captan, maneb, or zineb. Adding 1/4 teaspoon of a liquid household detergent to each gallon of spray helps insure complete foliage wetting. The first application should be made in early spring when the buds begin to open. A second application is necessary in June and a final spraying in August (Beecher et al 1964, Hepting 1971).

Additional information about these and other foliage diseases of flowering dogwood is given in a recent handbook by Hepting (1971).

Trunk canker, a stem disease most frequently found on low-vigor flowering dogwoods, is caused by the fungus *Phytophthora cactorum*. This disease is also called crown canker or collar rot. Twigs and large branches die as the disease progresses. Infected trunk tissues are discolored, and a black fluid often exudes from the canker. The canker slowly enlarges, extending completely around the base of the tree; and a collar of rot develops, eventually followed by the death of the tree. No satisfactory control for this disease is known. Small cankers, if detected in time, may be cut out and the wound dressed, but large cankers usually cannot be removed successfully. This is a disease of ornamental flowering dogwood that often follows injuries such as those caused by lawn mowers or boring insects (Beecher et al 1964, Hepting 1971).

The most common stem disease of forest-grown flowering dogwood is the target canker caused by *Nectria galligena*. Only occasional trees are infected (Hepting 1971).

The most damaging insect enemies of the dogwoods are the dogwood borers. They feed in the bark and cambium but not the sapwood. The larvae frequently kill young trees, and reduce the vitality and kill branches on older trees. Trees infested with borers have swollen areas on the trunk near the ground or at the main crotches. Since larvae enter only through a definite break in the outer bark, all

injuries to the trunk and branches of a dogwood should be avoided to prevent infestation. Pruning wounds or injuries should be treated with wound dressing. Some borers enter terminal twigs. Dead twigs should be pruned back to healthy wood and the wound dressed. The pruned twigs should be burned to destroy the borers. The trunks of newly transplanted trees may be wrapped with crepe paper to protect these trees from borer attack through unnoticed injuries. Insecticides may be used to control the overwintering borers (Beecher et al 1964, Schread 1957, Westcott 1951).

Dogwood club gall is caused by infestation with midge larvae (*Mycodiplosis alternata* Felt) and has become serious in some areas. The orange-colored maggots overwinter in the soil under dogwood trees. Pink flowering dogwoods seem to be infested most often; serious infestation will stunt the trees and kill most of the flower and leaf buds that develop beyond the galls. Excellent control of the gall may be obtained by spraying with carbaryl at the rate of 2 pints per 100 gallons of water. The spray material should be applied at weekly intervals from late May until the end of June. Trees sprayed six times were free of galls (Schread 1964).

Dogwoods are usually desirable, but certain situations may warrant control of these plants. In the South, complete control has been obtained by the application of picloram at the rate of 0.7 pounds per 100 gallons of spray. Leaf-stem application produced the best results. The degree of coverage by the spray material on thickets of dogwood was not critical (Nation and Lichy 1964). Picloram plus 2,4,5-T ester, 1½ pounds of each per acre, was also effective; 74 percent of flowering dogwoods were top-killed at the end of the second growing season after treatment (Brady 1969). But 2,4,5-T alone resulted in a lower kill of flowering dogwood, 22 percent, when helicopter-sprayed at the rate of 2 pounds acid equivalent per acre on logged and uncut areas in West Virginia (Wendel 1966).

In the South, flowering dogwood was successfully controlled by injection of 2,4-D amine concentrate (Moyer 1967) and was reported as susceptible to either 2,4-D amine or

fenuron pellets (*Cech and Mulder 1964*). However, in recent observations in West Virginia, flowering dogwood was highly resistant to treatment with fenuron (25 percent) pellets broadcast at rates of 20, 40, and 60 pounds per acre. Each treatment readily killed the overstory oaks, whereas the dogwoods responded to being released by growing and fruiting vigorously during the 4 years of observation after the treatments. This observation, and another in Pennsylvania (*Shipman and Schmitt 1971*), shows that fenuron can be used successfully to release flowering dogwood

and other shrubs overtopped by low-value hardwood trees.

Flowering dogwood is beneficial in limiting movement of nutrients (particularly calcium) through the soil profile, thus keeping them available in the rooting zone of other species (*Thomas 1967*). Having a very high content of calcium in the foliage, flowering dogwood often creates its own high soil pH. Dogwood litter decomposes very rapidly, thereby making it a prime soil builder when compared with low-calcium species such as oaks or pines (*Hepting 1971*).

GRAY DOGWOOD

GRAY DOGWOOD, *Cornus racemosa* Lam. Also called Gray-Stemmed and Panicked Dogwood.

By Stephen A. Liscinsky

*Pennsylvania Game Commission
State College*

RANGE

This species occurs in all but the northern and easternmost parts of the region. It grows from central Maine to southern Ontario and southward to Maryland, West Virginia, Kentucky, Missouri, and Oklahoma.

HABITAT

The wide range of gray dogwood indicates the many climatic conditions it will tolerate. Its ability to grow on a variety of sites is equalled by few other shrubs. In central Pennsylvania alone it is found from moist lowlands to dry uplands in medium- to heavy-textured soils (Heyl 1954). The top 4 inches of soil in these Pennsylvania sites had the following ranges in characteristics: pH 4.6 to 7.8; percentage organic matter 1.3 to 5.0; phosphorous 0.0 to 7.5 ppm; and potassium 15 to 338 ppm (Heyl 1954).

Gray dogwood is most commonly found growing in thickets along fencerows and woods edges and in abandoned fields. Although found mostly in pure thickets, it will persist for a considerable time in mixtures with other species. Hawthorns, elms, and ashes are common overstory associates, while grasses, sedges, goldenrod, and cinquefoil are common ground cover companions (Liscinsky 1960).

LIFE HISTORY

In June or July the shrub is often covered with small pyramidal clusters of little creamy-white blossoms, which are followed in September and October by showy clusters of white berry-like and brightly red-stalked fruits. If not eaten by wildlife, the fruit persists long after the leaves have fallen. Gray dogwood is well known for producing good to heavy crops of seed annually. Dissemination of the seed is largely credited to wildlife, especially birds.

Gray dogwood thickets seem to originate at a central point from seedlings that in turn spread by means of root suckers.

Gray dogwood is a slow-growing shrub. At 10 years of age a stand of gray dogwood is seldom more than 6 feet in height, with maximum stem diameters of 1 inch. At about 20 years it reaches its maximum height of 9 feet and stem diameters up to 1½ inches. Maturity is reached at this time, and the stand either gives way to more tolerant, longer-lived species, or regenerates itself if there is no competition. Stand density decreases from 120 to 20 stems per 100 square feet from ages about 5 to 15 years (Liscinsky 1960).

Tolerance to shade is considered intermediate. Removal of some overstory competition has been found beneficial to gray dogwood.

USE BY WILDLIFE

The fruits of gray dogwood are readily eaten by wildlife, especially by birds. Gray dogwood is an important cover plant for woodcock and ruffed grouse. Woodcock use thickets of gray dogwood from spring to fall for nesting, feeding, and resting. Grouse may be flushed from these thickets at any time of the year, but there is no record of nesting in them. For food and cover for wildlife, and its many other desirable attributes, gray dogwood is a highly desirable plant for wildlife. Deer browse the plant, but it is low on the preference scale.

PROPAGATION

Seed and stock are usually available commercially, but less available than other dogwoods such as flowering and silky dogwoods. Seeds average about 12,000 per pound, and average germination in tests was 31 percent, though a potential of 50 to 75 percent can be expected (*U. S. Forest Service 1948*). Dogwood seeds are dormant and require several months of warm, moist treatment before cold stratification for satisfactory germination (*Heit 1968*). The ideal way to handle the species is to collect mature fruit, clean the seeds, and plant them in early August (*Heit 1968*). In one case, seeds collected green in July and sown immediately gave full germination the next spring. Cleaned seeds may also be stratified and held for planting in April or early

May. For long-term storage, seeds should be cleaned, air-dried at low humidity, placed in sealed containers and kept at 34 to 38°F (*Heit 1967e*). Seed stored this way will retain excellent germination and vigor for 4 to 8 years (*Heit 1967e*).

The seeds are usually sown in drills, sometimes broadcast, and are covered with $\frac{1}{4}$ to $\frac{1}{2}$ inch of soil. Forty seeds per square foot are recommended (*U. S. Forest Service 1948*).

I had some success in planting 1-year-old seedling stock, but recommend 2-year-old stock. Success was definitely better on the more fertile soils and where the sod was removed before planting (*Liscinsky 1960*).

Generally speaking, success in planting this dogwood has not been as good as with others. However, most dogwoods can be grown from seeds, from root cuttings, by layering, and by division (*U. S. Forest Service 1948*).

MANAGEMENT

Management of this species is not difficult. Emphasis should be placed on caring for stands that become established naturally. This involves provision for some direct sunlight and elimination of some competing trees. Growing in thickets, adjacent to hawthorn and alder patches, this species is especially beneficial to wildlife. Establishment by planting should be reserved for areas where no gray dogwood exists and where the soil is suitable.

RED-OSIER DOGWOOD

RED-OSIER DOGWOOD, *Cornus stolonifera* Michx. Also called Hartes Rouges, Kinnikinnick, Red-Stemmed Cornel, and Squawbush.

By Margaret Smithberg
University of Minnesota
St. Paul

RANGE

Red-osier is most common in glaciated areas of the northeastern and midwestern states and provinces. South of the glaciated areas, it occurs locally near Washington, D. C., and in West Virginia, Ohio, Illinois, Indiana, Iowa, and Nebraska.

HABITAT

Although optimum conditions for the species have not been described, red-osier dogwood is somewhat restricted by high temperatures. Its southernmost limit is Washington, D. C., while in Canada it extends up to the tundra lines.

The species is characteristic of swamps, low meadows, and river and creek banks. However, it is also found commonly in drier situations such as fields and woods borders and may be cultivated in drier soils (*Grimm 1952*).

It is highly adaptable to soil type, being found for example on rich-woodland soil, silt loam, fine sandy loam, poorly drained muck, gravelly sand, boulder till clay, sandy upland soil, calcareous gravel, dolomite sandstone, heavy clay with peat, bottomland silt, and dry humus peat.

Red-osier dogwood, as a dominant member

of "edge" vegetations, is also adaptable to soil reaction. It is tolerant of alkaline soils (*Van Dersal 1938*) and was found in a wide range of pH values: 8.0 near lake outlets, 6.0 for sedge and northern white-cedar swamps, and 3.2 for sphagnum mats (*Jewel and Brown 1929*).

Since red-osier dogwoods growing in the poorer soils are likely to grow slowly and produce less fruit, the characteristics of soils that yield vigorous growth are more useful in choosing high-quality planting sites or suitable nursery soils. A Wisconsin sampling of vigorous stands led to these soil fertility standards for red-osier dogwood: pH 5.0-6.0, base exchange capacity 6.0 M.E./100 g., total nitrogen .07 percent; and these amounts of nutrients in pounds per acre: N-15, P₂O₅-75, K₂O-150, and replaceable calcium-1,200 (*Wilde 1946*).

The species plays a major role in many plant communities. It is commonly present along stream banks and shores with alder, birch, and willow, and is a dominant in wet lowlands with sedges, poplars, and black spruce. It is one of the earliest shrubby plants to become dominant in bogs and swamps, due to its ability to live with its roots often immersed in water (*Conway 1949*).

In moderately moist situations, it is found

with mountain maple, alder, meadow rose, and blackberries. It often invades grasslands, where it produces single, very large plants (Stallard 1929). Along forest margins, between forest and moist areas especially, it assumes an invader's role, as do hazel and gray dogwood. But where the latter two remain marginal, the red-osier dogwood soon extends into the moister regions.

LIFE HISTORY

Flowering occurs in May-June, but second flushes of bloom are common in late summer. The fruit, which is white to lead-color, ripens from July to early fall. The seed may germinate in the following spring or may lie over until the second spring.

Data are not available on the age for commercial seed-bearing (*U. S. Forest Service 1948*). The typical ages of first fruit-bearing, among unshaded or lightly shaded plants in Connecticut, were 4 years for wildlings and 3 years for nursery stock. Fruit yields were small compared to older plants (*Spinner and Ostrum 1945*). Little is known about geographic differences in seed production; however, in a species with such a wide distribution it is quite likely that differences exist.

Number of cleaned seeds per pound varies: 13,800 to 26,700 (*U. S. Forest Service 1948*) and 17,300 (*Van Dersal 1938*). The seed is heavy and is thus spread mostly by birds.

The species reproduces in a number of ways. As its specific name denotes, it produces stolons (runners). In a study in various habitats, this form of reproduction was noted primarily in very moist situations and in wet sedge meadows (*Smithberg 1964*). Reproduction also occurs from stems touching or growing under the ground, from seed, and even by shoot growth from roots. It was observed that when a branch is near death, a new branch may arise from the base of the old one. This occurrence accounts for the large many-stemmed forms often found.

Growth is fairly rapid. An average plant measured at the end of the first growing season, under clean cultivation, grew 443 inches of twigs (1,125 cm among all branches over three cm long) (*Smithberg and Weiser 1968*).

The average plant height the first season was above 3 feet.

When found in meadows with close grass cover, the species tends to remain in single large plants, because layering cannot occur.

Light intensity no doubt plays an important role in limiting the spread of red-osier dogwood. It is suppressed in shade and thus is never a dominant understory plant (*Spector 1956, Stallard 1929*). Under shade conditions it often reaches a height of more than 10 feet.

USE BY WILDLIFE

The species is commonly browsed by deer (*Dahlberg and Guettinger 1956, Meagher 1958, Murie 1951, Smith 1964*). I noted in Minnesota that the species was preferred over gray dogwood when they were found growing together.

At Isle Royale in Lake Superior it is an important winter browse for moose (*Hosley 1949*). In Montana it is browsed extensively by elk, in winter, and by mountain goats (*Murie 1951*). Black bear and beaver include it in their diet (*Martin et al 1951, Rue 1964*), as do mule deer, cottontail rabbit, and snowshoe hare (*Van Dersal 1938*). Fruit, wood, and foliage are utilized.

Red-osier also provides food for many songbirds and upland game birds. In New England it was found in the diet of 93 different bird species (*McKenny 1933*). It is a favorite fall food of ruffed grouse (*Bump et al 1947*) and is one of the preferred foods of both pheasant and turkey (*Korschgen 1960*).

The fruits of the species are readily identifiable in stomach analyses because of the unique two-celled character of the nutlets.

Red-osier dogwood is an important cover species for birds. In a study of vegetation and animal use of power line rights-of-way, the species provided dense summer cover, and the winter stems provided partial cover (*Gysel 1962*). It is an important cover for pheasant (*Korschgen 1960*) and is commonly found near ruffed grouse drumming logs in lowland vegetation types (*Palmer 1961*).

In fishery management, red osier is recommended for streambank plantings to stabilize eroding banks and to provide shade and coole

water for summer protection of fish (Black 1954).

PROPAGATION

Plants of *Cornus stolonifera* are often available commercially. However, *Cornus alba sibirica*, a very closely related plant, is much more common. Some taxonomists feel that the two are one species, *Cornus stolonifera* on this continent being a geographic variant of the Eurasian *Cornus alba*.

Propagation is possible either from seed or cuttings, and each source can be handled in various ways. With seed, the first option is fall versus spring sowing. Though this choice will usually be made before seed collection, the collection, cleaning, and storage of seed should be about the same in either case. Fruits should be collected when fully ripe (late July-October), because plantings of immature seed have shown reduced germination. If viability testing is to be done, red-osier, along with other dogwoods, requires use of embryo excision, tetrazolium chloride, or other special cutting tests (Heit 1967c). Cutting-test results in the range of 80 to 92 percent have been reported (Swingle 1939).

Seeds should be cleaned and air-dried if they are to be stored. The yield of cleaned seed is 15 to 20 pounds per 100 pounds of fruit, and the number of cleaned seed per pound averages about 19,000 (U. S. Forest Service 1948).

Fall sowing can be done in September-October or earlier. If dry, the seeds should be soaked, at least, before planting (Heit 1968). Soil recommendations are given in the life history discussion above.

The spring planting option requires storing and stratifying the cleaned, dried seed. Storage in sealed glass containers at 34 to 38°F for 4 to 8 years produced good germination, after stratification. The seeds have an embryo dormancy, which can easily be broken by stratification in sand, peat, or a mixture for 90 to 120 days at 41°F (U. S. Forest Service 1948) or longer, 120 to 140 and up to 290 days at 32° to 50°F (Chadwick 1935, Laurie and Chadwick 1931).

Some lots of seed may have hard-coat as well as embryo dormancy obstacles to germi-

nation and may require mechanical scarification before stratification (U. S. Forest Service 1948). Hard seed that has not been scarified may not germinate until the second spring after planting (Laurie and Chadwick 1931). Germination-test results have ranged from 6 percent for untreated seed (Swingle 1939) to 76 percent for stratified seed (Chadwick 1935, U. S. Forest Service 1948).

In the nursery, seeds are usually sown in drills at the rate of 40 viable seeds per square foot and are covered with ¼-inch of soil. The beds are usually mulched with leaves or straw, which is removed at the first sign of germination (U. S. Forest Service 1948). In one case, the yield per pound of cleaned seed was 2,979 plants when seed was spring-sown after stratification for 155 days at 40°F (Swingle 1939). One-year-old stock is usually large enough for outplanting (U. S. Forest Service 1948).

Use of cuttings or layering are practical alternatives to propagation from seed. Both softwood and hardwood cuttings root satisfactorily (Laurie and Chadwick 1931). No treatment of the cutting material is necessary. Cuttings taken in early August rooted 100 percent in 5 weeks. Hardwood cuttings taken in mid-April and immediately set in the field rooted 90 percent in 8 weeks (Doran 1957). A wholesale nursery in Minnesota takes hardwood cuttings either in the fall or spring, plants them in 1½ x 2-foot spacing in sandy loam beds, irrigates only when necessary, and obtains about 60 percent rooting. The cuttings are ready for transplanting after one growing season (Gordon Bailey, personal communication).

Although treatment is not essential, over 90 percent rooting was obtained in hardwood cuttings 6 to 8 inches long which were dipped in indole butyric acid (500 ppm in talc), planted in sand, and intermittently mist-sprayed (Smithberg 1964). Sand was a better rooting medium than peatmoss for potted cuttings of various dogwood species (Vermeulen 1959).

Layering is also a common practice. Branches are held to the ground with hooks and covered with loose soil. Rooting occurs after several weeks. A shoot rooted in this manner is merely cut from the parent plant and transplanted to the desired location (Hartmann and Kester 1959).

MANAGEMENT

The ease by which the species can be propagated and its fairly rapid growth on open moist sites makes it a desirable choice for streambank planting and wildlife cover adjacent to farm ponds (*Chapman 1947a*). It is also commonly used for windbreaks, gullies, and field and woodland border plantings (*Graham 1947*).

Planting trials in New York led to conclusions that red-osier can be used interchangeably with silky dogwood (*C. amomum*) in all

but the driest sites. Red-osier fruited more abundantly and somewhat later than silky dogwood, but not enough later to provide winter food for wildlife. Most of the wildlife use of both species apparently was feeding by songbirds. Both species showed good survival and growth (*Smith 1964*).

Red-osier dogwood can be controlled by spraying mixtures (in either oil or water) of 2,4-D and 2,4,5-T. Mixtures of dicamba and either 2,4-D or 2,4,5-T have also been recommended.

ELDERS

AMERICAN ELDER, *Sambucus canadensis* L. Also called Blackberry Elder, Common Elder, Elder, Sureau Blanc, and Sweet Elder.

SCARLET ELDER, *Sambucus pubens* Michx. Also called Red or Red-Berried Elder, Stinking Elder, and Sureau Rouge.

D. Michael Worley
Ohio University
Athens

and

Charles M. Nixon
Ohio Department of
Natural Resources
New Marshfield

RANGE

Both species occur throughout most of the Northeast. Scarlet elder is more widely distributed northward, from Newfoundland to Alaska, but becomes localized southward, notably in northern Ohio swamps and the Appalachian highlands of West Virginia and Kentucky. American elder ranges from Cape Breton west to Manitoba, and south to Georgia, Louisiana, and Oklahoma (Braun 1961, Fer-nald 1950, Gleason 1963c).

HABITAT

Each species grows under a variety of conditions so that one or the other is acclimated to practically all the extremes that occur in the Northeast. Scarlet elder is less adapted to warmer climates than American elder and southward becomes localized to the cooler uplands or swamp forests (Braun 1961).

Both species tolerate saturated soils. American elder usually occupies well-drained slightly acid soil (pH 5.5 to 6.0) bordering streams and in the adjacent bottomlands, but

also grows on gray forest soils and muck (Laurie and Chadwick 1931). Horticultural varieties of American elder succeed best in rich, moist, sandy soils (Judkins 1945). American elder has been found growing up to 4,000 feet in the southern Appalachians (Ritter and McKee 1964).

Scarlet elder grows in circumneutral soils (pH 6.0 to 8.0) and is somewhat more tolerant of dry soils and somewhat less adapted to saturated soils than American elder. Scarlet elder is often found on rocky soils (Hottes 1931), and in the Adirondacks is usually found where mineral soil has been exposed (Webb 1959).

American elder ranges almost throughout the eastern deciduous forests (Braun 1961). In upland mixed, moist-site communities, it is associated with witch-hazel, maple-leaved viburnum, ironwood, spicebush, and hophornbeam, and is most commonly found in the early successional types. In bottomlands, willow, alder, sycamore, and elm are common associates (Braun 1950). In oak-hickory communities, American elder is associated with hazelnut, spicebush, wild hydrangea and coral-

berry; and in the oak-chestnut community with gray dogwood, rose, New Jersey tea, and grape (*Braun 1950*).

Scarlet elder is seldom found south of, or lower in elevation than, the beech-maple forest zone, and in the southern portions of the region is restricted to higher altitudes in this community (*Braun 1961*). Scarlet elder is also associated with the hemlock-white pine-northern hardwood communities. Shrub species found with scarlet elder in these forests include American fly honeysuckle, beaked hazel, hophornbeam, and winterberry (*Braun 1950*). In the beech-maple and spruce forests of the Appalachian highlands, striped and mountain maple, hobblebush, and winterberry are common shrub associates (*Braun 1950*).

LIFE HISTORY

Both species bear separate male and female flowers on the same plant. Flowers usually occur on second-year and older canes and are arranged in clusters of compound cymes. Scarlet elder flowers from April through May, and the fruits ripen from June through August. American elder flowers from late June into August, and the fruits ripen from late July into September. Seed dispersal occurs from July to October in American elder and June to August in scarlet elder (*Park 1942*, *U. S. Forest Service 1948*).

American elder usually bears seed on second-year and older canes, but horticultural varieties grown from seed will occasionally fruit the first year (*Ritter and McKee 1964*). In Connecticut, wildlings first bore fruit at 3 years of age (*Spinner and Ostrom 1945*). The life span of individual canes is 3 to 5 years (*Deam 1932*). No information is available on youngest or oldest seed-bearing age of scarlet elder.

Information about fruit production is sketchy. In West Virginia, both elder species were checked during four consecutive years. There were no crop failures, and 70 to 80 percent of the plants bore fruit. Among 19 plants of comparable sizes, averaging 0.40 to 0.47 inch dbh, American elder produced about five times as much fruit, by volume, as scarlet elder (*Park 1942*). Scarlet elder may have alternate light and heavy fruit crops, and may

be more variable in fruit yield than American elder (*U. S. Forest Service 1948*).

Seed dissemination for both species is usually through ingestion by birds and mammals. Passage through pheasants inhibited seed germination of American elder, but passage through song birds increased subsequent germination (*Krefting and Roe 1949*).

Elders reproduce from seeds, sprouts, layers, and root suckers; but establishment in new areas comes mainly from seed. Once established, runners of both species tend to persist through vigorous resprouting (*Ritter and McKee 1964*). Seedling growth is rather slow during the first year; seedlings of American elder grew only 2 inches in 45 days (*U. S. Forest Service 1948*). After the first year, growth is rapid for individual canes of both species, often as much as 15 feet (*Ritter and McKee 1964*). Sprout growth is much more rapid than growth from seed, and is most rapid in the first year after sprouting. Mature plants average 3 to 10 feet in height.

American elder grows best in full sunlight; scarlet elder is more shade-tolerant (*Chapman 1947e*). Once established, both elders soon outdistance herbaceous competition. Thickets of both species are replaced by more shade-tolerant species during the later stages of forest succession, but individual plants and small runners will persist under a forest canopy.

USES

At least 50 species of song birds relish the fruit of American elder during summer and early fall, and at least 25 species eat the fruit of scarlet elder during the summer (*Van Dersal 1942*). Wild turkey, bobwhite, quail, mourning doves, ruffed grouse, and ring-necked pheasants also eat the fruit during late summer and early fall (*Martin et al 1951*, *Van Dersal 1938*) as do red squirrels, rabbits, woodchucks, foxes, opossums, skunks, chipmunks, whitefooted mice, and raccoons (*Chapman 1947e*, *Martin et al 1951*). White-tailed deer feed on twigs, foliage and fruit of both species during the summer (*Martin et al 1951*), and moose have been observed browsing scarlet elder (*Van Dersal 1938*). American elder rates higher on deer food preference lists from four northeastern states than on those

for southern states. Samples of American elder, collected in Louisiana and North Carolina, had higher percentages of crude protein (leaves 18, stems 7, and fruit 14) than most other browse plants (*Hankla 1961*).

New growth of American elder contains a glucoside that is occasionally fatal to livestock (*Hankla 1961*) and may influence deer utilization of elder. In the northern Lake States, a clipping study of scarlet elder showed erratic responses to heavy clipping in November. Capacity of the plants to withstand browsing was about equal to that of red-osier dogwood and mountain ash. Elders should be only moderately browsed each year (*Aldous 1952*). Cottontail rabbits, woodchucks, and red squirrels have been observed feeding on the bark of common elder during fall and winter (*Martin et al 1951*).

Elders provide fair escape cover for wildlife; and American elder has been ranked outstanding, along with grape and bittersweet, as nesting cover for small birds (*Petrides 1942*). American elder is thicket-forming, but the foliage of individual plants is quite open and the stems are bare. Scarlet elder is less apt to form thickets and offers less cover. However, during summer, the partial shade under American elder promotes a dense ground cover of grasses and forbs that offers good loafing or feeding areas for broods of young pheasants and quail (*Chapman 1947e*). In Ohio, elder thickets in bottomlands are often used by ruffed grouse broods during summer. In northern Ohio, wintering flocks of mourning doves roosted in a mixture of elder, sumac, blackberry, and dogwood found in openings within a pin oak stand (*Hennessy and VanCamp 1963*).

Both elders have been recommended and used for wildlife purposes in landscaping home grounds and roadsides (*Curtis and Wyman 1933, Holweg 1964*). Elderberries, of course, are also attractive to makers of pies, jams, and wine.

PROPAGATION

Seeds or rooted cuttings are available commercially, particularly for American elder, but seeds are not usually utilized for commercial propagation (*Mahlstede and Haber 1957*). Wild seed can be harvested from July through

September and should be collected as soon as fruits ripen. Commercial seed consists either of dried fruit or clean seed. Seed soundness and purity for American elder averaged 80 and 92 percent respectively. For scarlet elder, soundness averaged 97 percent and purity 98 percent (*U. S. Forest Service 1948*).

Fruit of American elder contains three to five one-seeded nutlets (*Krefting and Roe 1949*). Yields of cleaned seed per 100 pounds of fruit were 7 to 18 pounds for American elder (14 samples) and 4 pounds for scarlet elder (6 samples). Average numbers of cleaned seed per pound (14 samples) were 232,000 for American elder and 286,000 (6 samples) for scarlet elder; ranges were 175,000 to 324,000 and 192,000 to 377,000 respectively (*U. S. Forest Service 1948*). Cleaned and dried seeds of both species showed little or no loss in viability after nearly 2 years of storage in sealed containers at 41°F. Scarlet elder seed also retained viability for 1 year when stored in moist sand at 41°F (*U. S. Forest Service 1948*).

Seeds of both species exhibit variable degrees of hard-seededness and embryo dormancy. Scarlet elder is more difficult to germinate than American elder, but both require pretreatment for good germination during the first year. As preparation for spring sowing, seeds can be scarified with sulfuric acid for 10 to 20 minutes (American elder) or 10 to 15 minutes (scarlet elder), washed, and then prechilled at 36 to 40°F for 2 months (*Heit 1967a*). As an alternative to the acid treatment, a warm/cold stratification in moist sand was effective for American elder. The sequence was 60 days at 68 to 86°F alternating daily, then 120 days at 41°F. A longer period of cold stratification, 150 days, was less desirable because seeds began to germinate at 41°F after 120 days. Also, freshly collected seed showed less dormancy than seed from dried fruit (*Krefting and Roe 1949*).

Scarlet elder seed may germinate more uniformly if given a combination of the treatments above; acid scarification, 3 to 4 months of warm stratification, and 2 months of moist prechilling (*Heit 1967a*).

For late summer or fall sowing of fresh seed, acid treatment, as described above, should im-

prove germination in the following spring. Untreated seeds sown in late fall ordinarily do not complete germination until the second year (*Heit 1967a*). Fall-sown seedbeds should be well mulched because freezing does not favor after-ripening and may kill seeds that have imbibed water (*Davis 1927*).

American elder seed can be sown in drills, 35 viable seeds per linear foot, and covered with $\frac{1}{4}$ inch of soil. Germination rates as high as 80 to 85 percent have been attained. Beds of scarlet elder seedlings should be given half shade (*U. S. Forest Service 1948*).

Elders can also be propagated from hardwood cuttings taken from vigorous 1-year-old canes. Cuttings should vary in length from 10 to 18 inches, include 3 sets of opposite buds, and be taken in the spring as soon as the ground can be worked (*Ritter and McKee 1964*). Cuttings may also be taken in the fall, placed in moist peat or sphagnum moss, and held in cold storage at approximately 40°F for spring planting (*Mahlstede and Haber 1957*).

One-year-old seedlings or rooted cuttings of both species are usually large enough for field planting (*U. S. Forest Service 1948*). American elder should be planted in moist, rich, slightly acid soil, preferably in low swampy areas in a sunny location. No information is available about success of direct-seeding or the pretreatment of planting areas. If herbaceous growth is rampant, scarification should improve seedling survival. Scarlet elder is more tolerant of shade and soil conditions and may be planted on a variety of sites. However, in the southern portions of the Northeast, scarlet elder may not succeed at lower elevations or away from the beech-maple community (*Braun 1961*).

MANAGEMENT

Elders may serve best as nesting cover and a summer and early fall food source for birds. American elder seems superior to scarlet elder for such purposes, but is more demanding in its site requirements. Mixtures of the two species may be desirable, particularly where the site is partly shaded or the soil is less moist than that preferred for American elder. Mixtures are also recommended for contrast in decorative landscape plantings--particularly as tall background shrubs in fairly moist, partly shaded locations (*Curtis and Wyman 1933*). Pond and stream margins are among the best locations for both species (*Chapman 1947c*).

American elder can be used, at least partly, for erosion control on moist sites. It pioneers on some strip-mine spoils and may occasionally be useful for reclamation planting (*Chapman 1947e*).

Experience with cultivated varieties of American elder has shown that annual pruning will considerably improve fruit yield. Pruning should aim to leave five to six strong, 1-year-old canes and one or two older canes per runner. Removal of terminal shoots and dead canes will reduce winter-kill of terminal shoots and help control elder borers (*Ritter and McKee 1964*).

Both species fruit best in full sunlight, although scarlet elder will produce some fruit under a fairly dense canopy. Shading should be controlled if maximum fruit production is desired. Once established, the elders seem to outdistance herbaceous competition.

For wildlife management purposes, elders would seldom need to be killed; but they are susceptible to control by AMS or 2,4,5-T. They are intermediate in susceptibility to 2,4-D, and resistant to Amitrol, diuron, fenuron, and monuron (*Dunham 1965*).

SUMMER GRAPE

Vitis aestivalis Michx. and
Vitis aestivalis var. *argentifolia* (Munson) Fern.

Also called Blue, Bunch, Pigeon, and Silverleaf Grape.

By Lynn M. Shutts

USDA Soil Conservation Service
Moorefield, West Virginia

RANGE

Summer grape (including the variety *argentifolia*) ranges northward as far as southern New Hampshire to southern Minnesota—but not into Canada—and southward to Georgia and Texas. It is uncommon near the northern limits of its range. In West Virginia, summer grape is the most common grape species, and the variety *argentifolia* is nearly as abundant as the typical form (Fernald 1950, Massey 1961, Strausbaugh and Core 1958).

HABITAT

The optimum climatic conditions for summer grape have not been described, but grapes are subject to both cold and heat injury. A sudden temperature rise in late spring may result in damage to shoot tips. Spring frosts often damage foliage if warm weather and rapid growth precede a sudden temperature drop. Grapes do best under the moderately moist conditions necessary for adequate growth and resistance to disease. The primary damaging effect of excess moisture (rain or high humidity) is the enhancement of fungous diseases that destroy the fruit.

This species is generally restricted to upland areas (Hedrick 1908). The vines do well

on light, easily crumbled, shallow soils of old formation (Viala and Ravaz 1903). In Virginia, summer grape was found growing over a wide range of soil and site conditions (Shutts 1968). The pH requirements are variable.

Vines often occupy moist bench areas or ravines on southeastern slopes where organic matter has accumulated. Common associates are those species that occupy cove sites. Individual vines have been observed climbing in practically all species of hardwoods and conifers that occur within the range of summer grape.

LIFE HISTORY

The species bears male and female flowers on separate plants, and the flowers bloom from May through July. Pollen is disseminated by wind and rain. The fruit ripens to a dark purple in September or October (Massey 1961). Seeds are disseminated by wind action and by animals.

The plant is capable of producing seed the third season after establishment. The fruit crop is variable and often fluctuates greatly from year to year, but good crops occur in most years. Six vines with diameters ranging from 0.8 to 2.1 inches produced a total of 9-

334 individual grapes in one season. Approximately 40 percent of these grapes were affected by black rot fungus, which reduced their food value. The number of bunches per vine increased with the diameter of the vine (Shutts 1968). Dropping of fruit from the vines peaked during the first 2 weeks of November in the Ridge and Valley Province of Virginia (Shutts 1968).

Grapes may reproduce by means of seeds, sprouts, or layers. Terminal growth is very rapid, but lateral growth is slow. A vine 50 years old may have a diameter at ground level of only 1.5 inches.

The effects of sunlight on establishment are unknown. However, woodland openings, such as those produced by windfall or logging, appear to accelerate growth.

USE BY WILDLIFE

Black bear, raccoon, bobwhite quail, ruffed grouse, wild turkey, and a host of song birds eat grapes (Martin et al 1951). Deer browse the foliage and stems in the spring and early summer, and may consume large quantities of fallen leaves during the winter months (Massey 1961).

In summer, grape stands provide excellent escape and nesting cover for song birds. The vines may be so twisted and tangled as to effectively exclude predators.

Birds often use the stringy bark in nest construction (Martin et al 1951). Gray squirrels also build leaf nests with grape vine bark, and trees with grape vines in them appear to be preferred sites for leaf nests.

PROPAGATION

Seed is not available commercially, but may be collected in fruit traps made of polyethylene (Shutts 1968). Seed collection may be accelerated by shaking the bunches from the vines during late October and early Novem-

ber. During years of heavy fungus attacks, seed may be only 50 percent sound.

Grape seeds are not difficult to germinate, but plants raised from seeds may not be true to type (Hartmann and Kester 1968:384; Hosley 1938:339). Seed should be cleaned, stratified over winter, and planted in early spring. Good results have been obtained with a commercial species (*V. vinifera*) after a moist stratification period at 33 to 40° F for about 12 weeks before planting (Hartmann and Kester 1968:385). After 1 year in seedbeds, seedlings can be transplanted to permanent locations (Massey 1945).

Probably the most effective method of propagation is layering in early spring, because this produces new plants of known sex. Plantings should have at least one male plant for every three or four female plants (Massey 1961). Cuttings are low in rooting efficiency (25 percent). Grafting can be used to increase fruiting vines or pollen-producing vines where an improper balance is evident (Massey 1945).

MANAGEMENT

Summer grape is well adapted to grow in a variety of special situations such as over stone walls, rock piles, fences, spoil banks, or up over trees of poor quality (Hosley 1938:337). It could be used in most forest situations where production of wildlife food and cover were of primary importance. Grape stands may be effective in concentrating turkeys and grouse for harvest because the peak of fruit fall usually occurs in early November.

The best methods of maintaining grape stands are not yet known, but U. S. Forest Service studies about maintenance of grape stands have been initiated on the Jefferson National Forest, New Castle, Va. Grapevines are best controlled in large timber by severing the vines at their base. In small timber the herbicide 2,4,5-T can be applied as a foliage spray.

GREENBRIERS

COMMON GREENBRIER, *Smilax rotundifolia* L. Also called Bamboo-Brier, Biscuit-Leaves, Bread and Butter, Catbrier, Common Bullbrier, Devil's Hop Vine, Horsebrier, Hungry Vine, Roundleaf Greenbrier, Sowbrier, and Wait-a-Bit.

CAT GREENBRIER, *Smilax glauca* Walt. Also called Catbrier, Glaucous-Leaf Greenbrier, Sawbrier, Sarsaparilla Vine, and Sowbrier.

WITH NOTES ON

SAW GREENBRIER, *Smilax bona-nox* L.

LAUREL GREENBRIER, *Smilax laurifolia* L.

By Robert L. Smith

West Virginia University
Morgantown

RANGE

Eleven species of greenbrier occur in the eastern United States and Canada, but most grow primarily in the South; and only four species are considered here.

Common greenbrier is widely distributed throughout the East, from Nova Scotia to southern Ontario and Illinois, south to Florida and Texas. It is most common in the northeastern part of its range (*Gleason 1963*).

Cat greenbrier, the second most common species, has a more southern distribution, the northern edge of its range reaching into southern New England and New York, eastern Pennsylvania, and southern Ohio (*Fernald 1950*); it is most common in the southern part of its range (*Gleason 1963a*). Bristly greenbrier is widespread in the Northeast, but is

seldom abundant and is not discussed here because little information about it was available.

Saw greenbrier is chiefly a southern species that extends northward along the coast to Maryland and Delaware. Laurel greenbrier, an evergreen, is primarily a coastal species in the Northeast, occurring only along the coasts of Virginia, Maryland, and New Jersey (*Fernald 1950*).

HABITAT

The greenbriers are adapted chiefly for southern climates. In the North they are found principally on warmer and drier west- and south-facing slopes. Common greenbrier is the most common species in the Northeast; it grows on a wide range of sites from moist to well-drained to dry, although in the south it is

most abundant in low, damp flatwoods (*Goodrum 1961*). The optimum soil pH was reported as 5.0 to 6.0 (*Spurway 1941*). Cat greenbrier and saw greenbrier grow in a variety of soils and moisture conditions (*Goodrum 1961*), but in the Northeast cat greenbrier is characteristic of dry, well-drained soils (*Braun 1950*). In the highly dissected mountains of southwestern West Virginia, common greenbrier is widely distributed on south slopes and grows over the ridgetops and onto upper north slopes, but cat greenbrier is confined to south-facing slopes (*W. A. Van Eck and R. L. Smith, unpublished data*). Laurel greenbrier occurs mostly in low, wet grounds and swamps. It is most abundant in the bogs and pocosins near the coast from New Jersey to Florida (*Oosting 1956*).

Both common and cat greenbrier are pioneering successional species as well as components of forest understory vegetation. They commonly invade old fields, where they may be associated with sumacs, St. John's wort, black locust, sassafras, blackberry, blueberry, and bracken fern; and they remain a part of the understory when forest claims the site. Common understory associates are witchhazel, mapleleaf viburnum, grape, and flowering dogwood (*R. L. Smith, unpublished data*).

Although most greenbriers grow well in the shade, they generally do not grow or mature as rapidly, or produce as much fruit, as plants in the open (*L. K. Halls 1968, unpublished report*). Common greenbrier is more shade-tolerant than cat greenbrier, and good fruit crops have been noted in West Virginia for common greenbrier in 70 to 80 percent shade. Both species usually achieve maximum growth and produce the most fruit along the forest edge and in forest clearings where better moisture conditions may compensate for shading, or in old fields where they may cover the ground with dense spiny tangles. In Texas, young common and saw greenbrier plants yielded 11 or 12 times more browse in the open than in heavy shade from pines (*L. K. Halls 1968, unpublished report*). No such data for intermediate levels of shading are available; but in the Northeast, common greenbrier, at least, grows better than cat greenbrier in partial shade.

Shading of about 10 to 20 percent may be optimal for common greenbrier.

In the woods, common and laurel greenbrier tend to climb into trees. In the Northeast, common greenbrier rarely overburdens the supporting trees, and it seldom interferes seriously with tree or shrub regeneration. Cat greenbrier, however, often dominates other woody vegetation in old fields.

LIFE HISTORY

The greenbriers are climbing vines supported by tendrils that grow in pairs from the axils of the leaf. The male and female flowers, small and greenish yellow or white, are borne in small clusters on separate plants. In the Northeast, common and cat greenbrier bloom in May and June, and saw greenbrier from May to July. Laurel greenbrier flowers later, August and September, and its fruit does not ripen until October of the following year (*Fernald 1950, Gleason 1963a, Van Dersal 1938*).

The fruits of common, cat, and saw greenbrier ripen during September and October, the first year, into black berries covered with a whitish bloom. The fruit of common greenbrier usually contains 1 or 2 seeds, but may have 4. Cat greenbrier fruit may also have 0 to 4 seeds but usually has 1 to 3 (*F. L. Pogge, unpublished data*). In Connecticut, cat greenbrier fruited first at age 2 years among wild plants and at 1 year in nursery-grown vines (*Spinner and Ostrom 1945*). The canes, which live for 2 to 4 years, produce flowers after the first year, usually on the annual shoot growing from the upper part of the cane (*Goodrum 1961*). Fruits usually persist on the vines into the winter (*Park 1942*). Cat and common greenbrier fruits often persist until the next summer.

The fruits of common and cat greenbrier consist of about equal weights (oven-dry) of fruit pulp and seed (*L. K. Halls 1968, unpublished report*). Chemical analysis percentage for seed collected in Rhode Island and air dried were, for common and cat greenbrier respectively: protein 9, 11; fat 5, 8; crude fiber 19, 18; nitrogen-free extract 61, 57; ash 3, 5 and water 3, 4 (*Wright 1941*). Leaves and browse-stems of common greenbrier collected in North Carolina, Maryland, and Louisiana

have been similarly analyzed. Crude protein percentages ranged from 7 to 16 percent and varied with season and site factors as follows:

Higher	Leaves	Spring	Burned site	Open site
Lower	Twigs	Fall	Unburned	Woods

Fat content was generally low, 2 to 4 percent, except for one sample (6.1 percent) of leaves from Louisiana (*Blair and Epps 1969; DeWitt and Derby 1955; Halls and Epps 1969; Smith et al 1956*).

Although greenbriers reproduce by seed, common, cat, and saw greenbriers spread most rapidly by means of underground stems. The underground stems of saw greenbrier bear woody tubers growing singly or in clumps up to 6 inches across. Cat greenbrier has tubers and rhizomes, the latter possessing small prickles between the nodes. Common greenbrier lacks tubers, but has long, slender underground stems. Laurel greenbrier has hard and thickened tubers, but lacks true stolons (*Vines 1960*). These underground stems usually produce new canes annually, and the canes grow quickly.

Nearly all the annual growth of greenbrier stems is completed in a relatively short time. In Texas, common greenbrier started growth in early April, and 90 percent of the growth was complete by 1 May for plants in pine woods and by 20 May for plants in the open. Plants under the pines consistently started growth about 3 to 6 days earlier than those in the open. Mean length of "browse twigs" was 40 percent greater in the open than in the woods—probably representing a real but not statistically significant difference (*Halls and Alcaniz 1972*). There may be some dieback in late summer and fall (*Halls and Alcaniz 1965b*). Clipping and browsing stimulate production of new shoots; up to 60 percent of greenbrier annual growth can be browsed without injury (*Schilling 1938*). Even when all the new monthly growth was removed, common and laurel greenbrier were highly tenacious species in Texas (*Lay 1965a*).

Common and laurel greenbrier sometimes form almost impenetrable spiny thickets. Saw and cat greenbrier are more open and straggling in their growth form, but cat greenbrier often forms dense low tangles in old fields.

USES

Of all vines and shrubs in the Northeast, few if any outrank the greenbriers for wildlife food and cover. The fruit of greenbrier is eaten by at least 38 species of non-game birds (*Martin et al 1951*), such as the catbird, crow, mockingbird, thrasher, robin and other thrushes, white-throated sparrow, phoebe (*Hausman 1931*), and pileated woodpecker (*Hausman 1928*). Common greenbrier and cat greenbrier are important in the winter diet of ruffed grouse, especially in the central and southern Appalachians (*Gilfillan and Bezdek 1944; Nelson et al 1938*) and are taken in the same area by the wild turkey (*Bailey and Rinnell 1968, Martin et al 1939, Mosby and Handley 1943*). Greenbrier fruits are also eaten by sharp-tailed grouse, prairie chickens, and ring-necked pheasant (*Van Dersal 1938*). Greenbrier seeds may also serve as grit for game birds.

Greenbriers are among the most important deer browse plants, especially in the southern and central Appalachians, where they are utilized throughout the year (*Blair and Halls 1968, Dalke 1941, Goodrum 1961, Lay 1969, Ripley and McClure 1963*). The greenbriers are highly palatable to deer (*Halls et al 1957, Halls et al 1969*), and are exceptionally succulent. Even in fall the twigs contain no more than 32 percent dry matter. And greenbrier browse is relatively high in protein. Deer require a daily protein intake of 13 to 16 percent (dried weight) for growth, and 7 percent for maintenance (*Magruder et al 1957*). The leaves of greenbrier provide sufficient protein for animal growth during the early flush of plant growth in the spring (*Blair and Halls 1968*), and the twigs contain sufficient protein for maintenance in spring (*Blair and Epps 1969*). Protein levels decline steadily throughout the summer, but remain above the amount needed for maintenance until the leaves fall.

In winter the twigs supply, or nearly supply, the needs for maintenance. Laurel greenbrier, since it is an evergreen and leaves are available as browse through the year, adequately supplies maintenance requirements of deer; and the twigs of common greenbrier may also meet maintenance needs during winter. Twigs of common greenbrier collected in Mary-

land contained over 10 percent crude protein in winter (*DeWitt and Derby 1955*), and twigs collected in North Carolina contained over 13 percent crude protein in winter (*Smith et al. 1956*). Twigs of common greenbrier collected in Louisiana, however, contained only 7 percent crude protein in winter (*Blair and Epps 1969*). Like most woody browse species, greenbriers contain adequate amounts of calcium, but are deficient in phosphorus (*Blair and Epps 1969*).

Greenbriers also withstand and respond well to heavy browsing. Up to a point, the more the canes are browsed, the more additional growth they add. Thus, palatability, nutritional quality, and availability make greenbriers important in the management of white-tailed deer in the Northeast as well as in southern United States.

Rabbits also browse the leaves and twigs of greenbriers, especially those of common and cat greenbriers (*Blair 1936 Trippensee 1938*).

For covering tree stumps, trellises, etc., and for an impenetrable fence along property boundaries, horticulturists suggest the common greenbrier as a desirable species (*Everett 1960, Taylor 1948*).

Native North Americans and early pioneers used the roots of some greenbriers as food. They pounded the roots to a pulp, washed them in water, strained this, and allowed the sediments to dry into a fine reddish powder. This powder, after boiling in water, produced a jelly-like pudding. The meal was also used to make bread or cakes, fried in bear grease, and to thicken soups (*Gibbons 1970*). The young shoots of the four greenbriers discussed can be eaten raw as a salad or cooked like asparagus tips. Greenbrier extract was once used as a mild diuretic.

PROPAGATION

Because it is generally considered a nuisance, much more emphasis in the literature is placed on the eradication of greenbrier than on its propagation (*Fernald 1950, Strausbaugh and Core 1952, Taylor 1948*).

A recommended method of propagation is to divide and plant the roots in spring. The soil should be firmed about the roots and kept thoroughly moistened (*Everett 1960*). Canes may not appear from the rootstocks until the second year (*Goodrum 1961*).

Some greenbriers can also be propagated from stem cuttings. In Texas, cuttings about 6 inches long were taken in May when the twigs were actively growing and the leaves were fully expanded, in September when the growth was over and the wood was partially matured, and in January (*Halls and Alcaniz 1965a*). All leaves except two terminals were removed from each stem; the cut ends were dipped in a solution of indolebutyric acid, set upright to a depth of 2 inches in a 3 to 1 mixture of sand and peat, and the cuttings were shaded 30 percent and mist-sprayed regularly. Rooting success was 55 percent for common greenbrier. Saw greenbrier rooted erratically (32 percent), cat greenbrier rooted poorly, and laurel greenbrier did not root at all. Cuttings taken in May generally rooted better than those taken in September, but the latter month is better suited to out-planting in the spring (*Halls and Alcaniz 1965*).

Greenbriers can be propagated from seed, but optimal procedures are unknown. Howard (*1915*) obtained 51 percent germination of common greenbrier seed in 38 days. The seeds had been cleaned, dried, and stratified outdoors over winter, during which time they were exposed to freezing. Common and saw greenbrier seed in Texas responded well to cleaning and stratification in moist sand at 40 F over winter. Seeds were planted in early spring and lightly covered with soil. Seedlings were ready for transplanting after 1 year in the nursery (*Lowell Halls 1970, personal communication*).

Fruit and seed data supplied by Franz L. Pogge for 52 samples of common greenbrier and 35 samples of cat greenbrier collected at various sites near Morgantown, West Virginia were:

<i>Item</i>	<i>Common greenbrier</i>	<i>Cat greenbrier</i>
Fruit size, inches	1/8-7/16	3/16-7/16
Seeds per fruit:		
Usual number	1-2	1-3
Range	0-4	0-4
Sound seed, average	1.33	1.90
Seed soundness, percent*	51-89	74-94
Fruits per pound, average	1,825	1,550
Sound seed/pound fruit:		
Average	2,425	2,950
Lowest	1,600	2,050
Highest	3,750	3,525
Clean sound seed/pound, average	9,225	9,775

*Excluding one aberrantly low sample for each species.

In current studies (*July 1972*) by the Northeastern Forest Experiment Station, common greenbrier was fairly easy to propagate from seeds, stem cuttings, and root cuttings, but cat greenbrier showed promising results only from tubers collected while dormant (*Franz Pogge, personal communication*).

MANAGEMENT

Greenbrier grows in partial shade, in the open, and on a variety of soils. However, maximum growth of twigs and production of fruit is usually obtained from plants in the open. This suggests that a major management practice should involve release of vines from overhead shade. This would increase fruit production and the quantity and quality of browse.

When canes become too tough or grow out

of the reach of deer, new growth can be stimulated by cutting or disking, and by prescribed burning (*Goodrum 1961, Lay 1956*). The underground stems are highly resistant to fire, and new shoots develop quickly (*Lay 1956*). Prescribed burning increased both forage production and protein content of common greenbrier. High-intensity fires produce the highest quality browse. Protein content of browse increased 8 percent after low-intensity fire, and 19 percent after a high-intensity fire (*DeWitt and Derby 1955*).

Eradication or control of greenbrier by cutting is usually ineffective. Individual plants may be eliminated by digging out the roots; but for species as aggressive as greenbrier, this may be impractical. Cat greenbrier has proven rather difficult to control by herbicidal sprays. It is moderately to completely resistant to granular borate TBA applied at the rate of 275 to 400 pounds per acre (*Woestemeyer 1963*), and to fenuron at the rate of 16 pounds per acre (*McCully 1958*). Effective control of greenbrier was obtained by foliar and stem sprays (in water) of 2,4,5-T at 2 pounds acid equivalent per acre (*Elwell 1961*). Common greenbrier was controlled (kill of 95 percent) by spraying with 2,4-D plus 2,4,5-T in oil at 1 to 20 in 1 part oil and 3 parts water applied to the stems and foliage in July (*Niering 1961*). Saw greenbrier was rated susceptible to AMS only, among 9 herbicides (*Dunham 1965*).

HAWTHORNS

Crataegus L.

Also called Cenellier, Haw, Pommettes, Red Haw, Thorn, Thorn-Apple.

By Ward M. Sharp

USDI Bureau of Sport Fisheries and Wildlife
Warren, Pa.

SPECIES

Hawthorns comprise the largest single group of shrubs and small trees in the Middle Atlantic States and Northeastern States and Provinces. Because of the hawthorn's complex nature, the genus is divided into 19 series; and species representing 17 of these series occur in the Northeast. Regional floras or manuals are recommended for identification of the hawthorns. "The Illustrated Flora of the Northeastern United States and Adjacent Canada" (Gleason 1963c), and "The Flora of West Virginia" (Strausbaugh and Core 1953) are particularly helpful because of their illustrations in addition to the keys.

Hawthorns are medium to tall shrubs, 5 to 25 feet in height, with round, dense crowns in some species; crowns of other species are generally cylindrical or conical. Upon close-up inspection, hawthorns are distinguished by the presence of straight or slightly recurving, smooth, hard thorns on the woody branches; and sometimes additional multi-branched thorns on the larger main stems. The presence of stout thorns is a year-round characteristic that distinguishes hawthorns from other shrubs and small trees. The sweet crab apple

[*Malus coronaria* (L.) Mill.] is often mistaken for a hawthorn, but the short thorns in the crab apple arise from the apex of a short, leaf-bearing, spur-like branch.

After mid-August, the small, herry-like fruits of most hawthorns turn reddish to red. Only a few species have yellow or yellowish fruits. The later-ripening species retain their fruits after leaf drop; and, in years of heavy crops, the red fruits impart to the crown a reddish tint that serves as a further distinguishing mark in this season of the year. The red fruits of the deciduous hollies, especially common winterberry [*Ilex verticillata* (L.) A. gray], also impart a reddish tint in their crowns in autumn.

RANGE

Hawthorns occur throughout the Northeast in pastures, in fence rows on farms, and on idle lands in rural areas. Western sections of Pennsylvania and New York, for example, have a rich hawthorn flora, both in numbers of species and abundance in local areas. Hawthorn abundance is associated with areas where farms were operated for livestock as well as row crops. In areas where row crops

prevailed, hawthorns are uncommon: but, in localities where grazing of livestock was important, hawthorns are common to abundant. In the coastal and piedmont provinces of the region and in the sprawling megalopolis, intensive clean farming and the abundance of eastern redcedar (*Juniperus virginiana* L.) have limited the hawthorns' distribution and abundance.

HABITAT

Hawthorns are well adapted to the climate of the Northeast. Ohio, Pennsylvania, and New York have the greatest array of species; at least 60 percent of all species in North America may occur in these states. Hawthorns are both cold-hardy and drought-hardy except in the flowering period, when the female flower-parts (styles and stigmas) are vulnerable to frost.

The numerous species of hawthorns are adapted to a broad range of soil types, ranging from fertile calcareous soils to acid soils of sandstone origin and low N-P-K content. Hawthorns generally prefer moist or well-drained sites, especially the latter; but sites water-logged in spring support a number of species.

Hawthorns require full sunlight for optimal growth. They are intolerant of shading, and wane and die off when overtopped by a tree canopy. Being tall shrubs, they convert open grassland to a savanna-type community where grasses and forbs are continuous in the ground layer and the tall hawthorn shrubs are scattered throughout the site.

A unit of area populated by hawthorns is defined here as a stand. In Pennsylvania, stands occupied by hawthorns varied in size from 1 to 60 acres, with an average of about 4 acres (Hoover 1961). Past land-use practices determine the development of hawthorn stands. Land grazed by livestock favored hawthorn invasion and development. Cows relished the ripened fruits and disseminated the bony seeds in their dung, which nurtured the hawthorn seedlings and aided their establishment in sodded areas. Grazing by livestock prolongs the life of a hawthorn community.

The hawthorn stand is also a rich site for other shrubs and brambles. Such shrubs as

sweet crab apple, sumacs, dogwoods, junoberries, and blueberries occur in these communities. Old-field species of blackberries (chiefly those of the section *Arguti*) may develop clonal colonies.

Abandoned lands that were previously used for livestock operations are more productive of hawthorns than those used for row crops. But in the absence of grazing, trees usually invade and finally engulf the open land. Common tree invaders are those whose seeds are disseminated by the wind—ash, maple, elm, and pine. Black cherry also invades where seeds are brought in by birds. By repelling browsing animals, hawthorns protect other seedlings that grow up through them, and these invaders eventually shade out the hawthorns and dominate the site. Hawthorns—to their own detriment—are excellent nurse crops for invading trees.

LIFE HISTORY

In Pennsylvania, early flowering species generally begin blooming about May 5, and later flowering species come into full bloom in the first 10 days of June (Hoover 1961). Flowering dates are not identical from year to year because of annual variations in spring temperatures. Because the flowering period of different species extends over a month, late spring frosts would affect only those species in flower at the time of a freeze. In stands with only early-flowering species, for example, an early May frost could eliminate the fruit crop.

The fruits of early-flowering species ripen in late August, while those of late-flowering species ripen after mid-September. Fruits of early-ripening species have soft, pulpy flesh and do not have lasting qualities. Those ripening after mid-September have firm, fleshy fruits. Fruits of some of the latter species, upon falling to the ground and being covered by leaves or grass, remain firm into the following spring.

Seeds of hawthorns are hard, bony nutlets. When fruits are eaten by mammals or birds, only the pulp is digested, and the seeds pass through the alimentary tract. There are exceptions, of course, such as cud-chewing mammals or the larger game birds with gizzards efficient in grinding. Deer pass few seeds, if any, but cattle pass numerous seeds in their dung. In

ruffed grouse, the bony seeds appear to serve as grit, but many are found intact in droppings.

Hawthorns are propagated in nature by seeds. Three factors have been considered important for regeneration: availability of seeds, suitable germination conditions, and survival of seedlings (Hoover 1961). Hawthorn seedlings most commonly establish in grasslands. Best survival is in recently abandoned cow pastures or where grazing is light. Seedlings are unable to establish themselves in full shade.

Hawthorns may grow from a single stem, or two or more may arise from a base. The latter form is often the result of rabbit browsing in the seedling stage or crowding of plants growing side by side. Frequently two or occasionally three plants of different species may arise together, their crown branches forming what appears to be a single shrub. This trait can be confusing in species identification.

Once hawthorns attain about 2 feet in height, the sharp thorns in the compact crown, if hedged from previous browsing, create a barrier to livestock and deer. Cottontails may inflict heavy browsing on seedlings about 6 to 24 inches in height, but rabbits avoid taller plants as a rule.

Since hawthorns are shade-intolerant, they cannot compete with faster-growing trees or tall shrub regeneration that overtops or crowds the sides of the crown. In particular, the spreading, vigorous crowns of sweet crab apple often crowd and weaken hawthorns by shading the sides of their crowns.

INSECTS AND DISEASES

Hawthorns are subject to attack by both insects and diseases. Based on my hawthorn research, those species with thick, leathery leaves are the most resistant, while those with leaves of thin texture are the most vulnerable. Insect infestations are, as a rule, periodic and local. But the troublesome diseases may be an eliminating factor unless the source of infection is eradicated.

Several groups of insects attack hawthorns (Hoover 1961, Johnson et al 1966, Wiegell and Baumhofer 1948). Field studies indicate that the hawthorn lacebug (*Corythucha cydoniae*)

and the woolly aphid (*Eriosoma crataegi*) inflict the most damage over extended areas in Pennsylvania (Hoover 1961). Infestations of lacebugs destroy the chlorophyll by August, leaving the leaves brown and sere. Woolly aphids attack the branches en masse, probe into the cambial layer, and girdle or kill branches along one side.

Defoliating insects known to feed on hawthorn leaves are the tent caterpillar (*Malacosoma americana*) and the fall cankerworm (*Alsophila pomataria*). Outbreaks of the cankerworm are periodic, and only one severe attack on hawthorns was observed in Pennsylvania over a 16-year period. This infestation coincided with a regional irruption occurring across northern Pennsylvania during 1966 to 1968. After two successive years of complete defoliation, hawthorns became weakened and top dieback was prominent.

The hawthorn leaf-aphid (*Anuraphis crataegifoliae*) is a pest (Wiegell and Baumhofer 1948) that seems to cause only minor damage while leaves are succulent. I observed local damage to hawthorn stands by the seventeen-year cicade (*Magicicade septendecim*) in Pennsylvania. The female cicadas damage hawthorns when slitting the branches in the act of laying eggs. Their damage is local because of isolated nature of the outbreaks. The long interval between attacks permits the shrubs to recover.

Two rusts of the genus *Gymnosporangium*, two leafblights (*Fabraea maculata* and *Entomosporium thuemenii*), and fireblight (*Erwinia amylovora*) were reported as causing disease in hawthorns (Johnson et al 1966, Strong 1960). But these blights were not encountered on native species of hawthorns during field work in Pennsylvania (Hoover 1961). The English hawthorn (*Crataegus oxycantha* L.), its horticultural cultivars, and other exotic species are the principal targets for these blights (Inman 1962, Nichols 1958, Strong 1960).

Two eastern redcedar/hawthorn rusts, (*G. clavipes* and *G. globosum*) parasitize hawthorns. Of all the diseases, the hawthorn rust (*G. clavipes*) is the most destructive, infesting the leaves, fruits, and branches (Hoover 1961). The eastern redcedar is the alternate

host of these rusts. Wherever redcedar occurs, one can expect to find either heavily infested hawthorns, the remains of those that are dying out, or no hawthorns in the area. The cockspur hawthorn (*C. crugalli* L.) with thick leathery leaves, is one of the few native species whose leaves resist rust. Leaves of the series *Rotundifoliae*, which also are thick, resist damage. But the fruits of the above-mentioned hawthorns are damaged or eliminated by these rusts.

The control of diseases and insects infesting hawthorns requires comment. Attempts to eliminate rusts and leaf blights or hawthorns by use of chemical fungicides have been unrewarding (*Chapman and Schneider 1955, Strong 1960, Nichols 1958, Strong and Klomparens 1955, Inman 1962*). Applications of fungicide sprays were time-consuming and expensive; and results were temporary. The only permanent solution for the control of hawthorn rusts is to cut the infested redcedars. Several species of junipers are resistant to cedar rust (*May 1965*). These rust-resistant species should replace the redcedar in future estate and landscape planning. But the problem of values between established stands of hawthorns and redcedars becomes controversial when multiple land ownership is involved.

Leaf blights prove troublesome only among the exotic cultivars such as English hawthorn. Based on my extended field studies of hawthorns in Pennsylvania and New York, the native hawthorns are resistant to leaf and fire blight. Since insect infestations are periodic and local in nature, use of insecticides may prove more harmful to the total hawthorn community than the impact of insect outbreaks.

USES

The fruits of hawthorns are consumed by a number of birds and mammals, including upland gamebirds and songbirds, fur and game animals, and deer and cattle (*Chapman 1947b; Martin et al 1951*). The occurrence of hawthorn fruits in food studies varies partly because year-to-year yields are inconsistent. There may be good to bumper yields in a particular year, only to be followed by 1 or 2 years of poor yields.

A review of food studies of ruffed grouse in the region reveals that hawthorn fruits are a key item in their fall diet. The fruits are eaten by wild turkeys, beginning with the early-ripening species in August. A recent statewide study of white-tailed deer foods in Ohio showed that the fruits and leaves of hawthorns ranked 14th as a preferred food item (*Nixon et al 1970*). Cottontails feed on the fallen fruits, and songbirds utilize the fruits adhering to the branches in winter.

The leaves and succulent shoots of hawthorns provide palatable forage for deer and cattle. Heaviest use occurs in May and June, when shoot tips are succulent. Under heavy browsing, plants are hedged to 5 feet above ground. Cottontails browse seedlings under 2 feet in height throughout the year. Hawthorn use by cottontails in Michigan closely approached that of apple which was a highly preferred winter browse (*Trippensee 1938*). My recent study on the impact of browsing in a savanna community in northwestern Pennsylvania revealed that 85 percent of all hawthorns under 5 feet in height were browsed by deer or by cottontails.

Hawthorn stands serve as special habitat niches for upland wildlife. They are important brood-rearing areas for ruffed grouse and wild turkeys (*Sharp 1965*), and they form excellent woodcock coverts (*Liscinsky 1963*). In Ohio, abandoned fields reverting to hawthorns, sweet crab apple, and shrubby dogwoods—all staple deer foods—provide deer with their most productive feeding areas (*Nixon et al 1970*).

Hawthorns provide nesting sites for several species of birds, including brown thrashers, catbirds, robins, blue jays, and mourning doves (*Chapman 1947b*). The dense crowns of hawthorns afford protective cover not found in other shrubs or trees. The frail nests of mourning doves are amply anchored against storms. The thorny branches serve as a deterrent to nest predators such as mammals and possibly snakes.

In addition to providing food and cover for wildlife, hawthorns impart aesthetic appeal in the landscape. This large genus of shrubs presents a variety of crown forms, ranging from columnar, flat-topped to roundish outlines

(Hoover 1961, Watts 1946). Hawthorns have been used in landscaping estates, campuses, and other open areas. They contribute to landscape displays through the seasons by their white bloom in spring, their summer foliage, their crimson fruit in autumn, and the gray outlines of their crowns in winter.

Hawthorns are used for screening and for hedges. They have proved valuable in public camping areas for screening between campsites. An outstanding demonstration of this is the Forest Service's Buckaloons Recreation Area in Warren County, Pennsylvania. Hawthorn hedges serve as barriers because their thorns render them formidable. The same trait applies when used for screenings.

PROPAGATION

For those interested in improving wildlife habitat, the best solution to the problem of propagating hawthorns would be the establishment of nurseries consisting of native species. Such nurseries would provide an available source of the most valuable early-, medium- and late-ripening species. The seed source must be certified as to species; otherwise the

fruiting potential and adaptability of the stock may be low.

Commercial nursery stock is expensive, and hawthorn species offered for sale are usually either of exotic or unknown origin. Growing native hawthorns for commercial distribution no doubt entails financial risk on the part of the operator. Will the demand for hawthorns in wildlife plantings be of sufficient volume to warrant the establishment of hawthorn nurseries? Assuming that a nursery is a feasible economic undertaking, one must consider these factors for successful operation. First, a seed source of preferred native species must be located. Second, pretreatment of seeds before planting needs careful consideration. And third, the nursery must be protected against browsing by cottontails.

The fruiting potentialities and other qualities of native hawthorn in Pennsylvania and western New York have been under study during the past 16 years. Because of their annual yield ratings and site adaptability, those species named in table 1 are recommended for propagation in wildlife habitats. Other hawthorns that occur in the aforementioned states, but are not recommended, include 25 species or varieties in 11 series.

Table 1.—Hawthorns recommended for wildlife habitat

Common name	Scientific name ¹	Height, feet	Fruit availability
CORDATAE SERIES			
Washington hawthorn	<i>C. phaenopyrum</i> (L. f.) Medic	33-39	Fall-winter
CRUS-GALLI SERIES			
Cockspur hawthorn	<i>C. crus-galli</i> L.	to 33	Fall-winter
TENUIFOLIAE SERIES			
Large-seeded hawthorn	<i>C. macrosperma</i> Ashe	23-26	Fall-winter
Roan's hawthorn	<i>C. m. V. roanensis</i> (Ashe) Palmer	23-26	Aug.-Sept.
SILVICOLAE SERIES (THE MIDTHORNS)			
	<i>C. beata</i> Sarg.	20-23	Fall-spring
	<i>C. brumalis</i> Ashe	20-26	do
	<i>C. levis</i> Sarg.	10-13	do
	<i>C. populnea</i> Ashe	20-23	do
PRUINOSAE SERIES (THE PRUINOSE THORNS)			
	<i>C. compacta</i> Sarg.	10-13	Fall-winter
	<i>C. gallingeri</i> Ashe.	20-23	do
	<i>C. porteri</i> Britt	10-13	do
Frosted hawthorn	<i>C. pruinosa</i> (Wendl.) K. Koch.	23-26	do
COCCINEAE (THE LARGE-LEAVED THORNS)			
	<i>C. anomala</i> Sarg.	20-23	Aug.-Oct.
Ontario hawthorn	<i>C. pedicellata</i> Sarg.	20-23	do
Pennsylvania hawthorn	<i>C. pennsylvanica</i> Ashe	29-33	do

¹According to Ernest J. Palmer in *Fernald 1950: 767-801*; and *Gleason 1963b, v. 2: 338-374*.

The Washington hawthorn excels others for its consistent year-to-year fruiting. First, this hawthorn flowers after the first of June in central Pennsylvania when chances of frosts are nil. Second, its towering, columnar habit of growth enables it to compete better than other hawthorns with other woody vegetation. In hawthorn propagation projects, the Washington thorn should represent about a third of the planting stock.

Seed of native hawthorns is the most economical and dependable source of propagating material in wildlife habitats. However, the seeds usually exhibit double dormancy and may need special treatment to stimulate germination during the first spring after ripening. Scarification in sulfuric acid and two-stage stratification (warm-cold) have been recommended (*Flemion 1938*).

It is a standard nursery procedure to collect fruits in the fall and macerate them to remove seeds from the pulp. Cleaned seeds are dried to remove surplus moisture that would cause heating in storage under warm fall temperatures. Refrigerator storage of seeds is a common method of holding seeds, but this practice should be used only as a stop-gap measure before drying or stratification. Seeds should be mixed with sand, the mixture of sand and seeds placed in small wooden boxes lined with $\frac{1}{8}$ -inch hardware cloth, and the boxes stored outdoors for spring planting. But I have had good results by collecting the fruits, storing them outside over winter enclosed in hardware cloth trays (to protect them from rodents, etc.), and planting them into rows in prepared soil in the spring.

Direct-seeding in wildlife habitats and grafting are other methods in hawthorn propagation. Poor results or long waiting periods are likely to result from direct-seeding. Grafting among the species of hawthorns has been successful, but there are drawbacks in matching height-growth forms. The Washington thorn attains a small-tree habit of growth. When this thorn is grafted to one of the low-growing shrubby species, the resulting grafted scion is stunted. The dotted or "gray" hawthorn (*Crataegus punctata* Jacq.) also has a small-tree habit of growth. Since it is the most common and widely distributed hawthorn in the region,

grafting of the Washington thorn to this species is recommended.

Because of the hawthorn rust, propagation of hawthorns should not be attempted in areas where redcedar is abundant. The cockspur thorn is the only common species resistant to leaf rust, but even this species suffers rust damage to its fruits.

MANAGEMENT

This discussion will deal with maintenance of existing hawthorn stands, renovation of invaded stands, establishment of new ones, and the control of disease. Since other native shrubs of value to wildlife are usually associated with the hawthorns in the same sites, preservation and management of these other shrubs must also be considered.

Management of existing stands is a maintenance operation. Since hawthorns and many other shrubs thrive only during a temporary stage in succession, removal of tree invaders is necessary to retard encroachment. Removal consists of cutting invading tree seedlings, saplings, and trees where necessary. In some areas, the sweet crab apples will also need to be thinned to prevent them from crowding the hawthorns.

There are also former hawthorn stands that have been overtopped by sapling and pole-sized trees. Renovating these sites involves cutting the overstory trees. The operation is nearly always worth the effort because there is usually enough suppressed hawthorn regeneration to resurge; furthermore, these sites usually contain a good seed source in the soil.

Establishing new stands either from seed or nursery stock is a long-term project. Before wildlife values are realized, there will be a waiting period of several years, depending on the wildlife species. The project must have a clear objective as well as continuing interest to follow it through. If tree seedlings are also present, they may take over the site while the hawthorns are developing.

Cedar rust can be controlled by cutting the redcedars in areas where they are scarce. But in the Piedmont and Coastal areas, where redcedar is abundant, the job of control is futile. In these areas, the only solution is to go to a rust-resistant species of hawthorn.

HAZELS

AMERICAN HAZEL, *Corylus americana* Walt. Also called American Filbert, Coudrier Hassel, Hazel Brush, Hazelnut, Noisetier, and Wildfilbert.

BEAKED HAZEL, *Corylus cornuta* Marsh., formerly *C. rostrata* Ait. Also called Beaked Filbert, Coudrier, etc. as above.

By Forest W. Stearns
Department of Botany
The University of Wisconsin
Milwaukee

RANGE

Both hazel species are widely distributed in North America (*Gleason 1963b*). American hazel is found throughout the northeastern region save for the Maritime Provinces (*Fernald 1950*). It is common to abundant from Maine to Saskatchewan and southward to Georgia, Oklahoma, and Missouri (*Rosendahl 1955*). Beaked hazel has a more extensive and more northern range than American hazel. It is found from Newfoundland to southern British Columbia and southward to New Jersey and Pennsylvania, westward to Missouri, Ohio, Kansas, Colorado, and Oregon, and occurs in the mountains southward into northern Georgia (*Gleason and Cronquist 1963*). Beaked hazel is abundant in the northern Lake States, New York, New England, and the southern portions of Ontario, Quebec, and New Brunswick (*Rosendahl 1955*).

SPECIES

The hazel species are readily identified when in fruit but are difficult to distinguish in the dormant and vegetative condition.

Characteristics useful in identification are listed in table 1 (*Hsiung 1951, Wiegand 1909*).

Table 1.—Hazel identification

American hazel <i>Corylus americana</i>	Beaked hazel <i>Corylus cornuta</i>
Bracts of fruiting involucre broad foliaceous and toothed, open to the nut, downy.	Bracts of fruiting involucre united, much prolonged beyond the nut as a slender foliaceous beak, densely bristly*
Both twigs and petioles with glandular bristles (<i>hispid pubescent</i>)*.	Both twigs and petioles without glands, slightly pubescent.
Buds rounded at ends.	Buds acute.
Leaves rounded-cordate.	Leaves ovate to ovate-oblong.
Staminate catkins usually stalked, scales tipped with long reddish point.	Staminate catkins sessile or subsessile, scales with short light-colored tips.

*Smooth (nonglandular and without hairs) forms of both *C. cornuta* and *C. americana* have been described and are well distributed (*Fernald 1950*).

Corylus californica (A. DC.) Rose, of the Pacific coast, first described as a variety of *C. cornuta*, differs from it largely in having longer catkins, a shorter beak on the involucre, a thicker shell on nuts, and greater pubescence on the under side of leaves (Hsiung 1951). A variety of beaked hazel from the southern Sierra Nevada Mountains, *Corylus cornuta* var *Tracyi* Jepson, is characterized by leaves with little pubescence and a very short beak on the involucre (Jepson 1923). The only variety described for the northeastern region is *C. cornuta* var. *megaphylla* Marie-Vict. & Rous., which has larger leaves than *C. cornuta* (about 3.5 to 5.5 inches long and 2.5 to 3.5 inches wide) and a very long beak (Marie Victorin and Rousseau 1940).

HABITAT

Hazels are found in open woods, thickets, pastures, and clearings (Rosendahl 1955). Neither species grows well on poorly drained or organic soils such as mucks or peats nor on fine-textured soils such as clays or silt loams. Coarse sands are also unfavorable. Well aerated and light soils such as loamy sands, sandy loams, and loams support vigorous growth of both species. Hazel stands develop on these soils in association with a variety of forest types, including aspen-birch, northern conifers, and conifer-hardwood mixtures (Hsiung 1951).

Hazels are species of the early stages of forest succession. On lighter soils they persist in the mature conifer forest (Brown 1958, Hsiung 1951, Kittredge 1938). In New England and adjacent New York, beaked hazel is an important species in the successional sequence from abandoned pasture to mixed pine-hardwood forests. American hazel appears less tolerant of extreme cold, but beaked hazel is less well adapted to higher temperatures. Neither species is adapted to the climate of the Southern States or to the extreme north.

Beaked hazel grows best in slightly acid (pH 5.3 to 6.1), well drained, loamy sands and sandy loams in stands where 30 percent or more of full sunlight is available. A similar pattern holds for American hazel, although field observations indicate that it succeeds in

somewhat drier and sandier soils than does beaked hazel (Buckman 1964, Hsiung 1951).

Hazels, by virtue of an extensive and shallow root system, provide considerable competition for tree seedlings; and a dense hazel stand may crowd or shade out other plants. Below a dense hazel stand the light intensity may be only 2 to 7 percent of full sun, and competition for moisture is severe in the upper soil layers. Hazel in Minnesota is often a major competitor for young jack or red pine, and many studies have been made to devise means to eliminate it from young or regenerating stands (Brown 1958, Buckman 1964).

LIFE HISTORY

American and beaked hazel reproduce both vegetatively and from seed. After initial establishment, the plant may produce many aerial stems from underground stems or layers. Life-history information is limited and much of the following account is drawn from research (Hsiung 1951) at the Cloquet Forest Experiment Station, University of Minnesota. Available information pertains largely to beaked hazel; however, American hazel follows similar patterns.

Production of flowers and seed depend on plant vigor, which is in turn directly affected by forest stand and site conditions and by weather. Weather influences pollination, fertilization, and seed development. For example, a hot, dry spring adversely affects fertilization, and a late spring frost seems particularly effective in killing young ovules (Hsiung 1951). Shading also affects production. Many stems growing at low light levels never produce seed. The vigor of individual stems has more influence on flower production than does the vigor of the entire plant (Hsiung 1951). Thus, factors such as weather and overstory conditions account for large year-to-year fluctuations in fruit production. American hazel is said to have good seed yields every 2 to 3 years, whereas the interval for beaked hazel may be about 5 years (U. S. Forest Service 1948).

The male or staminate flower buds of beaked hazel are initiated early in the growing season and develop slowly until growth ceases in September, at which time the catkins are

evident as elongate buds. The female or pistillate flower buds are initiated later and are somewhat larger than the leaf buds.

Male and female flowers are produced on separate twigs before the leaves appear. Usually male and female buds are present on the same stem. Male catkins, one to three in number, are borne at the ends of the twigs formed in the previous season. Male catkins expand first. Soon afterwards small groups of female flowers develop from scaly buds, which will later form short leafy shoots.

Depending upon location, American hazel flowers in March and April, and the fruit ripens from July to September (*U. S. Forest Service 1948*). In Minnesota the two species flower and their fruit ripens during the same period, April and May and August and September respectively (*Rosendahl 1955*). The mature fruit is a round or ovoid hard-shelled nut surrounded by a husk (involucre) of two leafy bracts, partly or entirely fused.

Male flowers may be produced on stems only 1 year old and female flowers on 2-year-old stems. Flowering increases with stem age, reaching a maximum at 10 to 11 years, after which it diminishes gradually until it ceases at about 18 years. The flowering stems all appear to be of sprout origin, and little is known of the time required to produce flowers from stems of seedling origin in the wild—if indeed it does occur. Male flowers are formed in greater numbers and at an earlier age than female ones. In one sample of 1,224 stems, 53 percent produced male flowers and 29 percent female flowers. Production of both male and female flowers varies greatly even among stems of the same age.

In northeastern Minnesota, the average fresh weight of nuts of beaked hazel was about 1.3 g with a water content of 51 percent (*Hsiung 1951*). Average dry weights were reported (*U. S. Forest Service 1948*) as 0.9 g for American hazel and 0.8 g for beaked hazel (476 and 549 seeds per pound respectively). Weight of the mature nut varies greatly in both species. The range in number of cleaned seed per pound was 197 to 736 for American hazel and 425 to 676 for beaked hazel (*U. S. Forest Service 1948*). Nuts are disseminated primarily by small rodents such as chipmunks

and red squirrels, which often cut the green nuts in early autumn.

Seed production is not well documented, but fluctuates greatly between years. In one area, the number of beaked hazel nuts per acre varied from 13,000 in 1968 to only 44 in 1969. These estimates from a study near Rochester, Alberta, concern stands with 75 percent beaked hazel cover under aspen (*Doris Rusch, personal communication*). American hazel nut production was estimated as 3,000 per acre in Missouri in 1939 (*Dalke 1953*).

Seed production per stem has received only limited study. In most inflorescences only 1, 2, or 3 nuts matured in 60, 33, and 5 percent of the inflorescences respectively (*Hsiung 1951*). The number of inflorescences per stem is highly variable. In good years perhaps 6 to 8 nuts are produced on each fruiting stem (*Hsiung 1951*).

Seedlings are not often abundant in nature because seeds are destroyed by rodents or occasionally by insects or fungi. Some authors have found seedling establishment infrequent and attributed increase in density of hazel to sprouting from underground stems (*Buckman 1964, Hsiung 1951*). In other cases, spread was clearly by seed. A study of hazel in red pine stands revealed many individual clones, each of seedling origin; the older clones were not extensive, at 15 to 20 years of age they ranged in diameter from 2 to 55 inches. Spread by seed is a major factor in invasion of new areas, but requires a good seed source and (temporarily at least) a low rodent population (*Tappeiner 1971*). Dense stands of hazel appear to originate from the establishment of numerous seedlings which in turn produce many aerial stems.

Vegetative spread of hazel clones is slow but accelerates with age; at Cloquet, Minnesota, 6-year-old clones with one or two sprouts had an average diameter of only 0.8 inches, while 38-year-old clones reached 96 inches in diameter and averaged 25 living aerial stems (*Hsiung 1951*). Older clones produced larger and more vigorous sprouts.

Germination of beaked hazel seed is relatively poor. In a Minnesota study, only 26 to 32 percent of the nuts germinated when bur-

ied 1 inch deep in upland forest soil. Those buried in a black spruce-tamarack stand showed 56 percent germination while none germinated in a wet swamp (*Hsiung 1951*). Most other data indicate relatively low germination, between 30 and 60 percent, after cold stratification.

Seedling hazel develops most abundantly under an open forest overstory where nuts, often secreted by rodents, have escaped being eaten. Germination is highest where the nuts were covered sufficiently to prevent drying out during the winter after-ripening period. Buds form in the axils of the cotyledons early in the development of the seedling. These buds usually remain dormant for several years, but may develop immediately into upright shoots if the seedling stem is injured or dies.

As the seedling becomes established, it produces a taproot which penetrates deeply; simultaneously numerous horizontal roots grow into the surface soil. During the first few years, sprout formation is closely related to damage to the main stem; after the plant is well established, the frequency of sprouting increases (*Cheyney 1928, Hsiung 1951*). Plants receiving ample light and growing on well-drained soils generally produce a vigorous system of tap and lateral roots. Underground stems are initiated when the seedling is between 7 and 12 years of age. Additional new stems develop vegetatively from aerial stems, underground stems and layers; thus dense thickets of hazel may develop and are perpetuated by sprouting. Over 90 percent of the underground stems and roots are in the top 6 inches of soil (*Hsiung 1951*), and most of these structures are found in the humus layer near the surface of the mineral soil.

Beaked hazel clumps grow slowly at first. Ideally the clump should develop in a radial pattern, but chance and circumstances make this infrequent. In a dense stand one may find as many as 2,250 clones per acre, each producing sprouts (*Tappeiner 1971*). Rapid increase in stem density is often accompanied by an increase in mortality, the average life of an aerial stem in a dense and vigorous stand being relatively short (*Hsiung 1951*).

Sprouting is often stimulated by fire, which may kill the above-ground parts without destroying the underground system (*Buckman*

1964). In Minnesota, a light fire may increase stem density two to four times that of the original unburned stand. One stand 4 years after a spring fire had 40,000 aerial stems per acre, double the number before burning, while after 4 years of spring fires the stem density was 95,000 stems per acre (*Buckman 1964*). Only slow, hot, summer fires, which consume the duff and kill the underground stem systems, serve to eliminate hazel where it is not wanted (*Buckman 1964*). Heavy browsing by deer may stimulate sprouting. Sprout formation is usually followed by rapid growth; vigorous stems may reach heights of over 2 feet in two growing seasons. The average height at 15 to 20 years is about 8 feet. Growth in length declines as the stem ages, and annual growth is often less than 1 inch per year in decadent stems (*Hsiung 1951*).

Growth of beaked and American hazel is favored by ample light and moderate moisture. Neither species will germinate or grow successfully in wet sites nor under dense shade. Hazels grow vigorously in open pastures and brush types or under an overstory of red or jack pine, aspen, or aspen-birch and conifer-hardwood mixtures.

USE BY WILDLIFE

Hazels are important food plants for a variety of wildlife. Stems and twigs are a major component of winter browse for white-tailed deer in portions of the Lake States and presumably elsewhere, and are also commonly eaten by snowshoe hare (*Martin et al 1951; Van Dersal 1938*) and moose (*James M. Peck, personal communication*). Some evidence suggests that deer may use beaked hazel heavily, while American hazel is only lightly used. Neither hazel species is highly preferred browse (*Dahlberg and Guettinger 1956; Ross et al 1970*). However, as preferred species have disappeared, hazel has gained importance. At least 30 percent of all stems browsed in northern Wisconsin forests are hazel. Canopy area has been shown to be a good indicator of twig and leaf production (*Peck 1970*).

Winter browsing by deer may be severe, and an entire young hazel thicket may be mowed to snowline. More often, browsing is moderate to light and scattered, because deer prefer new

sprouts and vigorous shoots. In some areas, young hazel stems and leaves may also comprise as much as 30 percent of the summer food of white-tailed deer (*B. E. Kohn, personal communication*). Beaver make considerable use of hazel in some areas in the Northeast, and use by raccoon has been noted (*Martin et al 1951*).

Male catkins provide a rich protein source for ruffed grouse, especially in late winter (*Bump et al 1947; Gullion et al 1962; Korschgen 1966; Martin et al 1951*). Woodcock, sharptail grouse, and other birds make use of buds and catkins (*Martin et al 1951; Van Dersal 1938*) and the nuts are utilized by wild turkey (*Dalke 1953*). Hazel nuts are a major item of food for several mammals. Chipmunks, red fox, and gray squirrels begin their harvest when the nuts are filled but still green (*Hsiung 1951; Martin et al 1951*). These rodents cache the nuts in small piles or bury them individually for later use. Deer may eat the nuts if any remain after the rodent harvest is finished. In Alberta, aspen stands with hazel supported red squirrel (*Tamiasciurus hudsonicus*) densities approximately six times those found in pure aspen stands. Even so, hazel appeared to be a supplementary food, because highest adult red squirrel densities were found in spruce-fir forests. Captive red squirrels on a strictly hazel nut diet consumed an average of 80 nuts per day (*Doris Rusch, personal communication*).

In contrast to other nuts, hazel nuts are especially rich in protein and fats and correspondingly lower in carbohydrates (26.5, 61.4, and 7.2 percent of dry weight respectively). Hazel nuts are relatively much higher in protein and fat than are beechnuts, and beechnuts, in turn, exceed acorns by a large margin (*Wainio and Forbes 1941*).

Hazel clumps provide cover for both woodcock and grouse, especially where the stand is vigorous and well developed (*Korschgen 1966*). Large hazel clumps in fields or fence rows may furnish cover for deer, rabbits, and smaller mammals (*Martin et al 1951*). Dense hazel thickets with closely spaced stems serve ruffed grouse as upland brood range and as drumming habitat (*Gullion et al 1962*).

PROPAGATION

Both beaked and American hazel can be propagated by seed or vegetatively. Commercial use of these species is not frequent although the European filbert (*C. avellana*) is widely propagated. Beaked and American hazel as well as the closely related California hazel have dormant embryos and require stratification; even so, germination is usually low. This is not the case for the European filbert, which gives high germination after 60 days stratification. Propagation by seed in the field requires that seed be protected from rodents. Early autumn sowing is recommended (*Heit 1967c*).

Fruits should be gathered as soon as the edges of the husk begin to turn brown, or they will be lost to squirrels and chipmunks. The green fruits are spread out to dry, and after a few days the husks can be removed by flailing (*U. S. Forest Service 1948*). Avoid drying of the seed. American hazel seed will retain viability for 2 years when stored in a closed container at 41° F, but few beaked hazel seeds remain viable for this long. Stratification in moist sand at cool temperatures (36 to 40° F) serves as satisfactory overwinter storage. If seed is to be sown in the spring, stratification at 41° F for at least 90 days is essential and 120 days are recommended (*Swingle 1939*). Best germination in American hazel was shown in limited tests when seed was stratified, then held at 65° F for 67 days and returned to 41° F for another 30 days (*U. S. Forest Service 1948*).

Seedlings can be grown in the greenhouse where ample soil depth must be provided for development of the taproot. Greenhouse seedlings of beaked hazel averaged about 4 inches tall, bore either 6 or 7 leaves, and developed tap roots averaging 5 inches in length during the first growing season (*Hsiung 1951*). All species can be propagated vegetatively; horticultural varieties are propagated regularly by means of layers, sprouts, cuttings, or grafting (*U. S. Forest Service 1948*). Cuttings are made after the leaves have fallen and are kept until spring in sand beds. Cuttings should be planted just before bud break (*Dream 1932*).

MANAGEMENT

To date hazel management has been concerned chiefly with the elimination of beaked hazel, and especially American hazel, where the shrubs compete with pine seedlings. Techniques used have included mechanical destruction, fire, and herbicides (Buchman 1964, Klug 1960, Roe and Buchman 1963). If the underground stems are not destroyed, the treatment will usually result in at least a two-fold increase in the number of aerial stems. Based on this work, management for browse production seems feasible by using techniques shown to encourage sprouting: for example, spring burning at intervals of several years or mowing near ground level at intervals of perhaps 4 to 8 years. Both techniques seem to have merit if more preferred species are scarce.

Establishment of hazel clumps for wildlife seems practical especially if the area in question lacks other appropriate species and if soil and light conditions are suitable. As with most shrub species, reduction of overhead competition will increase stem vigor and stimulate both fruit and vegetative growth.

Management to increase nut production also seems feasible on fertile, well-drained soils in areas where hot, dry spring periods or late-spring frosts do not commonly occur. Management for nut production requires that a healthy stand of stems in the 6- to 15-year age class be maintained either in the open or under a light overstory. Hazel has been recommended as a plant for natural hedges and windbreak plantings where it will provide both food and cover to attract birds and small mammals (Dean 1932, Martin et al 1951).

HONEYSUCKLES

TATARIAN HONEYSUCKLE, *Lonicera tatarica* L.

JAPANESE HONEYSUCKLE, *Lonicera japonica* Thunb.

AMERICAN FLY HONEYSUCKLE, *Lonicera canadensis*
Marsh.

LIMBER HONEYSUCKLE, *Lonicera dioica* L.

HAIRY HONEYSUCKLE, *Lonicera hirsuta* L.

SWAMP FLY HONEYSUCKLE, *Lonicera oblongifolia* (Goldie)
Hook

MOUNTAIN FLY HONEYSUCKLE, *Lonicera villosa* (Michx.)
Roem. & Schult.

By Lawrence W. Jackson

*New York Department of Environmental Conservation
Delmar*

SEVEN SPECIES

The seven northeastern honeysuckle species of greatest value to wildlife (table 1), ranked in order of importance, are:

- Tatarian honeysuckle. Widely cultivated and naturalized, it is the most prolific fruit producer.
- Japanese honeysuckle. Widely naturalized, it provides dense escape cover for small mammals and birds, but it not so dependable a fruit producer.
- American fly honeysuckle. This is the most widely spread native honeysuckle in the Northeast.
- Limber honeysuckle. Its late fruiting provides food for migrant birds. It is widespread, but not as common as American fly honeysuckle.
- Hairy honeysuckle. It provides late fruit for migrant birds, but is discontinuous in range; branches recline on the ground and are not readily available to wildlife in winter.
- Swamp fly honeysuckle. Common in moist areas throughout the region, it is a poor fruit producer.
- Mountain fly honeysuckle. This is strictly a subarctic species, with low fruit production.

Table 1.—Honeysuckles: range, growth habit, and fruiting

Common name	Range	Growth habit	Fruit color, time of ripening, and availability
Tatarian honeysuckle	Eurasia. Escaped from cultivation. Ontario to Quebec, south to New England, New Jersey, Pennsylvania, Kentucky, and Iowa.	Erect shrub to 14 feet tall.	Red or yellow. Late June-Aug. to Nov.
Japanese honeysuckle	Asia. Naturalized, particularly near cities: Florida to Texas, north to New Hampshire, Massachusetts, Ohio, Indiana, Missouri and Kansas.	High twining or trailing shrub, half evergreen.	Black. Aug.-Nov. to Mar.
American fly honeysuckle or Canadian fly honeysuckle	Quebec to Saskatchewan, south to New Jersey, Pennsylvania, mountains to North Carolina, Ohio to northeast Iowa.	Straggling shrub 3 to 5 feet tall.	Red. July-Aug. to Sept.
Limber honeysuckle	Southwest Quebec and Maine to Manitoba, south to Georgia and Missouri.	Twining or reclining shrub. 1-2 feet.	Salmon red. July-Oct.
Hairy honeysuckle	Western Quebec and western New England to Saskatchewan, south to Pennsylvania, Ohio, Michigan, Wisconsin, Minnesota, and Nebraska.	Climbing or sprawling vine.	Red. Aug.-Sept. to Oct.
Swamp fly honeysuckle	Manitoba to southeastern Quebec, south to New Brunswick, northern and eastern Maine, northern and western New York, western Pennsylvania, northern Ohio, Michigan, Wisconsin, and Minnesota.	Erect shrub. 2 to 5 feet tall.	Orange-yellow to deep red. July-Aug. to early Sept.
Mountain fly honeysuckle	(Including varieties) Southeastern Manitoba to Hudson Bay to Newfoundland, south to New England, Pennsylvania, Michigan, Wisconsin, and Minnesota.	Depressed or ascending shrub. to 3 feet tall.	Blue. Late May-Aug.

The honeysuckles rank intermediate in value to wildlife. Deer, rabbits, hares, and mice feed on branches and shoots; and birds take advantage of the fruits in season. Japanese honeysuckle is the only one that provides exceptionally good cover for wildlife. The two exotics, Japanese and Tatarian honeysuckle, have been grown in many nurseries; and five of the seven honeysuckles have been widely cultivated. They sprout easily, are handily transplanted, can be grown from cuttings, and establish themselves readily. Most species adapt to a wide variety of soils and are shade-tolerant. Japanese honeysuckle is used for browse and tolerates moderate browsing. It has become a noxious plant in many areas, and control has become necessary. Honeysuckle fruits are available to resident birds during summer months, and to migrants during fall

and winter months. Japanese honeysuckle fruit persists even into March.

TATARIAN HONEYSUCKLE

Habitat

This species, a native of Turkey and southern Russia, was first cultivated in the United States in 1752. It has been planted throughout the eastern United States and southeastern Canada. Little is known about its climatic limitations, but it withstands climates where the temperature drops to -10 to -20°F in winter. This species, like Japanese honeysuckle, has naturalized itself in many places, but is hardier. Its range extends into Canada, beyond the range of Japanese honeysuckle. There is little literature to indicate the extent of spread of this species in southern states.

Tatarian honeysuckle will grow in a variety of soils with pH ranging from acid to alkaline, but the optimum pH range was reported as 6.5 to 8.0 (*Spurway 1941*). It grows on well-drained limestone out-crops (*Lee Chamberlain and Stuart Cameron, personal communication*) in northern New York. No information is available about topographic limitations.

This plant has a wide variety of associates because of its wide distribution. It would be unwise to say that it does best in this or that association because it is still escaping in many areas. In Canada it is found in open maple woods. Biologists have observed it in association with northern white-cedar and heath plants in northern New York; with open hardwoods and in abandoned fields in central and western New York (*Howard Bobseine and Fred Slater, personal communication*), and on the sand plains of Long Island (*John Renkavinsky, personal communication*).

In southern New England, Tatarian honeysuckle grows in several plant associations and on various soils (*Richard Howard, personal communication*). It also occurs in central Maryland on old-field sites and under yellow-poplar or other hardwood stands on good sites (*Silas Little, personal communication*).

Life History

Flowering takes place in June in Canada and New England and in May from New York southward. Twin flowers are born in opposing leaf axils. Flowers are pink to white and about 1.5 to 2 cm long. Fruits (berries) ripen in July and August and are normally red but sometimes yellow.

Of the seven honeysuckles discussed here, Tatarian is the best fruit producer, bearing abundantly in most years. The fruits persist into late summer and early fall and provide food for local and migrating birds. First fruiting occurs at 3 years in nursery-grown plants (*Spinner and Ostrom 1945*).

This is a rapidly growing, bushy shrub that reaches heights of 6 to 14 feet. It does not sprout from the nodes, as Japanese honeysuckle does, and therefore does not spread as rapidly. Seeds are readily eaten by birds and are carried to new locations in this manner. Tatarian honeysuckle withstands moderate

browsing by deer and cattle, and regrowth is rapid. However, after 3 years of heavy browsing, it has been eliminated in areas of high deer concentrations on Long Island (*John Renkavinsky, personal communication*).

Growth is exceedingly good in full sunlight, but maximum plant height in shaded areas is considerably less than that of plants in the open. Tatarian honeysuckle competes well with most other associated plants, particularly in open woods or fields. However, it seldom completely dominates a site as Japanese honeysuckle often does.

Uses

This honeysuckle is the most important one for production and availability of wildlife food. Deer, cottontail rabbits, and mice readily feed on the twigs and bark. The persistent fruits provide food for birds from July through November, so long as migrating flocks do not strip the bushes. Excellent cover is also provided by the bushy growth of this plant (*Gysel and Lemmien 1955*). It provides protection for small mammals, including rabbits and mice, and is ideal nesting cover for small birds.

Tatarian honeysuckle has some value as an erosion-control plant but does not compare with Japanese honeysuckle in this respect. As an ornamental, Tatarian honeysuckle is an excellent general utility species because it tolerates shade and various soil conditions. The plants are also prolific nectar producers and are often planted by bee keepers (*Smith 1946*).

Propagation

Seedlings and seed are available commercially. If seed is to be collected locally, it should be hand-picked or stripped from the shrubs shortly after ripening—to guard against loss to feeding birds. Seed yields were reported as 2 to 12 pounds per 100 pounds of fruit (average 5.5 pounds), and counts of cleaned seed averaged 142,000 per pound (*Swingle 1939, U. S. Forest Service 1948*). Seeds can be cleaned by macerating the fruit in water and floating off the pulp and empty seeds. Dried seeds can be stored in sealed containers at 34 to 38°F for up to 15 years with little loss in viability (*Heit 1967e*).

Seeds can be sown either shortly after ripening or in the spring. For spring sowing, stratification for 60 to 90 days at 40°F has been recommended (Hartmann and Kester 1968). After spring sowing, germination is usually complete within 40 to 60 days, or less if the seeds have either been stratified or given a water soak for 24 to 48 hours before sowing. Ordinarily, about 15 percent of the seeds sown will produce usable 1-0 seedlings (U. S. Forest Service 1948).

Seeds should be covered with $\frac{1}{8}$ to $\frac{1}{4}$ inch of nursery soil. Though nursery propagation is fairly easy, care must be taken to see that the soil is adequately drained, because the stems rot easily. The young plants grow best if fertilized and irrigated, and may be ready for out-planting as 1-0 to 2-0 stock.

Field planting sites should be well-drained and exposed to full or nearly full sunlight, and should be plowed or at least furrowed before planting. The seedlings will also need at least one cultivation after planting to reduce weed competition.

Though nursery production of Tatarian honeysuckle is almost entirely from seed, it and other honeysuckles can also be propagated from stem cuttings, either hardwood or early-spring. Rooting has been improved by treatment with IAA at 50 mg/l for 24 hours. Sand or sandy soils were recommended as rooting media (Doran 1957).

Management

Tatarian honeysuckle is most easily established as 1- or 2-year-old seedlings and will take almost anywhere. But growth on poor soils is much slower than on richer soils, and plants may take several years to attain maximum heights. On poor soils average heights are about 4 feet, on good soils 10 to 12 feet (Edminster 1950).

Although little maintenance and care is needed once the plants are established, weeding or release cutting, where needed, may improve growth and fruit production. Leaf lice (aphids) are a potential danger, and Russian authorities have tested insecticides on these pests (Gunkel 1965, Raukin and Trofimova 1967). However, little or nothing has been

done about pest control on this continent to date.

Control of this species is seldom necessary. Some experiments on the effects of selected herbicides on Tatarian honeysuckle have been made with varying results (Birdsell et al 1958). The insecticides and herbicides used to control Japanese honeysuckle have also been tested on Tatarian honeysuckle.

Miscellany

Spontaneous wild hybrids are not common in the genus *Lonicera*, but several species cross readily when grown together. Since hybrids are fertile, back-crossing is common. This is particularly true of *L. tatarica* (Greene 1966). Many of these hybrids are listed by Rehder (1940), Gray's Manual (Fernald 1950), and Flora of Sic and the Gaspé Peninsula (Scoggan 1950).

JAPANESE HONEYSUCKLE

Habitat

Introduced in 1806, this honeysuckle has naturalized itself over much of the eastern United States. It is particularly common in areas where it has been planted for ornamental purposes and for hedges. Four varieties have been identified, of which *halliana* is the most common.

Japanese honeysuckle adapts readily to a wide variety of climatic conditions. However, it is not hardy in cold climates in the Northeast. The species survives in sand plains in Louisiana (Brunett 1967) and oak forests of the Adirondacks (Greenleaf Chase, personal communication), as well as in a variety of intergrading climatic situations. It is naturalized in states or portions of states south of the 30°F normal January isotherm and north of the line where only 5 percent of January nights are lower than 32°F. At present it is limited to humid continental climates with warm summers and humid subtropical climates with no dry season. It rarely occurs above 1,200 feet elevation and has not escaped in mountainous sections of New England (Leatherman 1955). Also, in Massachusetts and part of New York, the tops freeze back almost every year. Optimum conditions appear

to be met where temperatures are moderate through the winter months and where precipitation is not excessive.

Japanese honeysuckle occurs in sand, sandy loam, loamy sand, and silt loam (Brunett 1967; Jack McCormick, personal communication). On Long Island it occurs in the heavier clay soils on glacial moraines (John Renkavinsky, personal communication). In Washington, D. C., it grows well on clay soils. The species also occurs throughout northern New York wherever soils are on limestone outcrops (Greenleaf Chase, personal communication). However, it is noticeably absent on coarse sands and the poorer peat soils (Silas Little, personal communication). Soil pH can range from about 6.0 to 7.5 (Orville Steward, personal communication). Best growth is reached on well-drained forest soils (Leatherman 1955) and plants spread rapidly where soils are rich in minerals and are within the pH range of 6.1 to 7.9. Topography appears to have little influence on distribution. However, the species has not been planted in many mountain areas and has not been introduced in Canada.

On Long Island, plant associates are black birch, hickories, flowering dogwood, poison ivy, bayberry, and blackberry. Goldenrods and hawkweeds are also common herbaceous associates (John Renkavinsky and Jack McCormick, personal communications). In upstate New York, associations are varied, depending on where the plant has been introduced. It is found in oak-pine associations; in white-cedar stands; in white, red, and pitch pine stands; and in stands of mixed hardwoods, particularly where openings have been created. It commonly grows in limestone outcrops in the upstate area in association with the above cover types. However, it is rare in spruce and fir types and coastal pine barrens. Japanese honeysuckle occurs in most plant associations in the Southern and Central States.

Life History

Flowering occurs from June through September in the Northeast (Richard Howard, personal communication), and from April through June in the Southeast. Occasionally blossoming takes place in March and July

through October in the southern states (Wilber Duncan, personal communication). Flowers are abundant and form in clusters in the leaf axils. The flower is white, tinged with purple fading to pale yellow, and is very fragrant.

Fruits ripen from August to November and are black at maturity. Fruit production is fairly heavy, and seeds are widely dispersed by animals and germinate readily. The fruit is eaten and digested by various birds and small mammals, but seeds pass through the digestive system and are eliminated quickly (Handley 1945). No data are available about seed production.

Plants occur as trailing, half-evergreen, woody vines with greatly elongated stems that root sporadically at the nodes. In the Southeast the plant is evergreen, but in the Northeast it is generally deciduous (Leatherman 1955). New stems originate from older rooted nodes so that complex layering of stems frequently results (Kammerer 1967). The plant is fast-growing and may rapidly dominate a site. However, heavy shade effectively reduces growth and development of mats, even though runners are present (Little 1967).

Best growth is attained in full sunlight, and fruiting is most profuse in open stands. Poor success of planted seedlings in Louisiana was partially the result of competing herbaceous vegetation (Brunett 1967). However, where Japanese honeysuckle has become established, it spreads rapidly and dominates the site. At the Kalbfleisch Field Research Station on Long Island, the species occupied as much as 80 percent of the main cover once established. In Tennessee, wild plum, black cherry, tree of heaven, red maple, flowering dogwood, and honey locust trees died as a result of competition by Japanese honeysuckle (Leatherman 1955). The plant's growth form effectively reduces sunlight and moisture available to other plants, and only the most competitive species can survive in association with Japanese honeysuckle. It may kill trees as large as 6 inch dbh (Kammerer 1967).

Uses

Deer, cottontail rabbits, bobwhite quail, ruffed grouse, wild turkeys, and songbirds use this species of honeysuckle, particularly as an

emergency winter food. Both fruit and vegetative growth are eaten by turkey and quail. Nutritive values (including crude protein, fat, nitrogen free extract, crude fiber, and ash) of fruits are equivalent to corn kernels, and growing vegetation is equivalent to timothy hay (*Handley 1945*). While Japanese honeysuckle is used as emergency food it is seldom a staple in the diet of birds and mammals that use it.

Japanese honeysuckle makes ideal cover for cottontail rabbits, quail, songbirds, cotton rats (*Leatherman 1955*), and wild turkeys (*Rainey 1949*). The evergreen foliage provides winter protection for these species except near northern limits of its range (*Wyman 1955*). The thick tangles of vines also provide excellent nesting sites for many species of small birds (*Handley 1945*).

It is commonly planted as an ornamental and for forming hedgerows. Cherokee Indians use the stems to make baskets and trays (*Leitch 1952*).

Propagation

Seedlings are available from some nurseries. Propagation is said to be easy, but I found no practical information in the literature.

Outplanting recommendations given for Tatarian honeysuckle are probably applicable to this species. However, field plantings should be carefully planned with regard to the aggressiveness of Japanese honeysuckle and the risk that it might displace other desirable species.

Management

Management of Japanese honeysuckle has evolved through a series of stages since its introduction to the United States in 1806. The plant was originally introduced as an ornamental and was used in landscaping around buildings. When game management evolved in the mid to late 1930s and early 1940s, game managers were looking for plants that provided abundant food and cover for wildlife. Japanese honeysuckle appeared to provide both of these features. As demand by game managers for planting stock grew, many nurseries increased their capacity for producing

Japanese honeysuckle from seed and cuttings. Even though seedling stock is still being distributed for planting, emphasis has now passed to studying various means of controlling the species where it is established. The Soil Conservation Service has recommended planting in cuts and fills where soil erosion is imminent. In 4 or 5 years the fast-spreading stems form a layering mat that stabilizes the soil.

Japanese honeysuckle establishes readily in most soils. Sand and sandy loam soils are particularly suited to the spreading nature of the plant. Studies at Devon, Pennsylvania, and at Kalbfleisch Field Research Station on Long Island have shown that Japanese honeysuckle will compete favorably with other plant species on old-field sites regardless of whether or not other woody vegetation is controlled. On one study plot at Kalbfleisch, mean cover increased from 21 percent in 1960 to 58 percent in 1967 where woody and other vegetation was controlled. On the undisturbed portion of the plot, mean cover increased from 9 percent in 1960 to 43 percent in 1967. Competition from other woody plants slowed but did not halt the spread of Japanese honeysuckle. Frequency of occurrence was also plotted in these studies because the honeysuckle overlapped and formed matted layers. Frequency on the managed section of the plot increased from 72 percent in 1960 to 88 percent in 1967. On the control section, frequency increased from 58 percent in 1960 to 90 percent in 1967 (*Keamerer 1967*; *Jack McCormick, personal communication*). In Louisiana, survival of plantings has been poor, but established plants seem to grow well. Studies are being made in Louisiana to determine the feasibility of supplementing winter wheat with Japanese honeysuckle as a winter deer food (*Brunett 1967*). It has been shown that the addition of potassium permanganate to heteroauxin solution increases rooting in honeysuckles (*Evenari et al 1946*). However, in southeastern states where Japanese honeysuckle and kudzu-vine (*Pueraria lobata*) are free-growing, establishment of tree seedlings is seriously inhibited because both vines form a dense mat of vegetation (*Brender 1960*).

Once plantings have become established, very little maintenance is needed. The critical

period is in the first year after planting, when the root system is adapting to a new soil. Various fertilizers have been tried, such as 12-12-12, 6-24-24, 0-20-20, ammonia nitrate, and nitrate of soda, on mixed plantings of wheat and honeysuckle in Louisiana. Effectiveness of the various applications was unknown because success of the honeysuckle plantings was poor (Brunett 1967).

Because of its ability to spread rapidly, to compete aggressively with other species, and its tenacity in dominating a site, control of Japanese honeysuckle has become a necessity. Several nonchemical approaches to control have been tried, including burning, isolation by grazing, repeated cutting, cultivation, and shading. Grazing, burning, and repeated cutting reduce the plant temporarily. However, some root crowns survive even the most intensive measures and soon establish full cover by rapid regrowth of sprouts (Little 1967b). Under a closed canopy, the plants are eventually shaded out (Leatherman 1955).

Use of herbicides has been by far the most effective control measure. Since 1950 a variety of herbicides have been tried, with varying results. Amine salt of 2,4-D, applied without addition of a spreader, caused 90 to 100 percent killing of Japanese honeysuckle growing in sparse stands in shaded areas. A kill of 50 percent or more occurred in dense stands 8 to 10 years old and exposed to full sunlight. The influence of light and time of year of spraying were more important than herbicide concentration. A respraying on 3 July was more effective than a single respray applied on other dates (Hitchcock and Zimmerman 1949).

Comparative studies of the effect of ammonium sulfamate, borax, and 2,4-D on poison ivy and honeysuckle were made in the National Capitol Parks, Washington, D. C. Treatments of borax and 2,4-D applied two or three times during the growing season effectively controlled honeysuckle under some conditions (Webster 1950).

Plant toxicity of insecticides, in mist concentrates, has been tested on a variety of shrubs. Five percent solutions of the insecticides were applied directly to the plant leaves. Most phytotoxic were malathion, lindane, heptachlor, chlordane, and DMC. Least phyto-

toxic were aldrin, isodrin, dieldrin, DDT, ovotran, chlorobenzilate, and compound 923. The genus *Lonicera* was the most susceptible in all cases (Clower and Matthysse 1955).

At Clemson University Research Center, 2,4-D and 2,4,5-T effectively controlled honeysuckle in yellow-poplar stands on bottom lands. In the southeastern United States, very rapid reinvasion of honeysuckle on bottomland sites was found; honeysuckle seedlings grew so rapidly that in 1 year the vines reached the top of a yellow-poplar 14 feet tall (Bruner 1967, 1968). Such rapid regrowth did not occur in Maryland, and various conditioning treatments permit the dominance of yellow-poplar seedlings over Japanese honeysuckle under most northeastern conditions (Little 1968).

To be completely effective, the controlling herbicide must destroy the honeysuckle plant. Various herbicides have been used to release pine or hardwood seedlings from competition of Japanese honeysuckle or to eliminate honeysuckle in areas being prepared for tree regeneration. Considering both the degree of honeysuckle control and the amount of damage to desired trees, 2,4-D emulsifiable acid, applied in late fall for release of hardwoods and in late summer or early fall for release of pines, is effective. A mixture of 2,4-D and picolinic acid applied during spring or early summer has been recommended as a conditioning treatment to prepare an area for new tree regeneration (Little 1968).

Present control methods are expensive, and attempts to develop more economical methods are needed (Brender 1960). Future research will probably emphasize biological control methods.

AMERICAN FLY HONEYSUCKLE

Habitat

As indicated by its range, this species is more cold-hardy than Japanese honeysuckle, but about equivalent to Tatarian honeysuckle. Fly honeysuckle thrives in cold climates, but southward of Pennsylvania it occurs only in the mountains.

American fly honeysuckle occupies both

acid and alkaline soils throughout its range, but does particularly well in acid soils in the southern portion (*Wilber Duncan, personal communication*). In the north it typically occupies dry, rocky woods, particularly in Ontario and Quebec (*Dorothy Swales, personal communication*). In upstate New York and New England, this honeysuckle occurs in a wide range of soils formed from granite and calcareous sandstones. On the north shore of Long Island, American fly honeysuckle is found on glacial outwash plains (*John Renkavinsky and Anthony Taormina, personal communications*). It does not thrive in dry, sandy soils.

American fly honeysuckle grows best in rich, damp woods where soils include an accumulation of organic matter, and may be most abundant in mountain areas where the soil has not been disturbed. The species can be found under northern hardwood and mixed hardwood/conifer overstories in New York and New England (*Greenleaf Chase, personal communication*). However, in the southern portion of its range, American fly honeysuckle occurs more frequently in moist rich soils under hardwoods, simply because hardwood stands are more abundant than conifer or mixed stands.

Common plant associates in upstate New York, New England, Ontario, and Quebec are serviceberry, witch-hazel, beaked hazel, viburnums, gooseberry, yew, red maple, sugar maple, striped maple, mountain maple, eastern hemlock, red spruce, balsam fir, aspen, birches, spirea, and sedges. On Long Island and the New Jersey coast, associates are serviceberry, flowering dogwood, and various sedges (*John Renkavinsky, personal communication*).

Life History

Flowering occurs primarily in April and May throughout the range. American fly honeysuckle is conspicuous as one of the earliest shrubs to leaf and flower. Flowers are scattered in leaf axils but occur in pairs. Blossoms are funnel-shaped, about 2 cm long, and yellowish-green to straw-colored. Fruits are red, fleshy, several-seeded berries that ripen in July and August. This species is not a prolific

producer of fruit. Wherever it grows in shade, fruit production is sharply reduced.

Regeneration of plants is by shoots from a spreading root system and from seeds eaten and transported by birds and small mammals. Seeds are scarified as they pass through the digestive tract of the animal or bird. Undoubtedly this species spreads more commonly by shoots from underground root systems than from seeds.

Growth form is erect, and the shrubs are 3 to 5 feet tall at maturity. Growth is more rapid in open sunlight than in shaded woods (*Richard Howard, personal communication*). However, American fly honeysuckle is shade-tolerant and persists even under thick cover. It competes favorably with its plant associates under most conditions but is not an aggressive plant like Japanese honeysuckle and will not dominate a site.

Uses

Moose, deer, rabbits, and hares make ready use of twigs and foliage of this plant. It is a preferred food of deer, particularly during winter, but rarely is their staple food because it does not occur as abundantly as the maples, viburnums, and other staples. Furthermore, it often is not available to browsing mammals in the northern portion of its range because of deep snow during winter. Ruffed grouse, quail, and small birds eat the fruits as they ripen in August (*Greenleaf Chase and John Renkavinsky, personal communications*). However, the fruit is not persistent and will not provide food for birds during late fall or winter (*Ralph H. Smith, personal communication*). American fly honeysuckle offers little value as a cover species. The open growth form provides little protection and the early fruit drop prevents small mammals and birds from using it in the fall. The species is rarely planted as an ornamental.

Propagation

American fly honeysuckle has been cultivated since 1641, but plants or seeds are not known to be available commercially. For local collection of seed, fruit should be hand-picked or stripped from the branches as soon after

ripening as possible. Since most *Lonicera* species hybridize, it is better to collect seed from isolated shrubs that have desirable characteristics. Seed is extracted by macerating fruit in water and allowing empty seeds and pulp to float away. After a short drying period, seeds are ready for storage (*U. S. Forest Service 1948*), preferably in sealed containers kept at 34 to 38°F (*Heit 1967e*).

Most of the natural germination of honeysuckles takes place in the spring after seed dispersal, but some species, notably Tatarian, may germinate in the fall, shortly after ripening. I found no specific recommendations for propagating American fly honeysuckle. However, general recommendations for the genus are that seed of lots showing embryo dormancy should be sown broadcast or in drills in the fall, or stratified before early spring sowing. Species of known impermeable seed coats should be sown as soon as possible after collection to insure germination the next spring. Nondormant seeds can be sown in the spring without pretreatment. This may be the best recommendation for American fly honeysuckle and limber honeysuckle, because outdoor stratification of these species for 83 days gave no practical benefits (*U. S. Forest Service 1948*).

Management

Since both food and cover values of the plant are low, it has seldom been considered in habitat-management plans. When established, the plant maintains itself well. Consequently no actual maintenance has been practiced by game managers on this species of honeysuckle, and it is unlikely that it ever will receive serious management consideration.

Honeysuckles are used as browse indicators for deer in winter concentration areas along with more staple species such as maples, viburnums, and beaked hazel.

LIMBER HONEYSUCKLE

Habitat

This is a versatile honeysuckle that adapts to a variety of climates throughout its range. It survives temperature extremes of 5 to 10°F. in the southern portion of its range and -35 to -50°F in the north.

Limber honeysuckle is found growing on a wide variety of soils. These include loam, sandy-loam, gray and red forest soils, and glacial till, and outwash plains. It is also present on calcareous soils and on well-drained quartzite sandstone where sunlight is abundant (*Greenleaf Chase and Dorothy Swales, personal communications*). Topographic limits are not known, but field observations indicate that limber honeysuckle grows best on sandy, well-drained plateaus above 2,000 feet in elevation.

In general this species is found in association with trees and shrubs of open, sandy plains and dry, well-drained woods (*Greenleaf Chase and Wilbur Duncan, personal communications*). In northern New York it does well in association with blueberry and white pine at Ray Brook in Essex County and on jack pine plains in Clinton County (*Greenleaf Chase, personal communication*).

Life History

Flowering occurs in late May in Canada and early April in the southern portion of the region (*Dorothy Swales and Wilbur Duncan, personal communications*). Flowers appear in one to three whorls at the end of leafy branches, and are greenish-yellow or straw-colored to brick red or purple. The fruits form in clusters of 3- to 4-seeded berries, which are salmon-red when they ripen, usually in August. This fruit sets well and is available to wildlife much longer than the berries of American fly honeysuckle. The seeds are enclosed by the fleshy fruit and are eaten with the fruit by wildlife. However, seeds are passed readily from the digestive tract of animals and birds.

Limber honeysuckle is a low-growing shrub, 1 to 2 feet tall, with decumbent branches that commonly twine around adjacent plants. Growth is fairly rapid on sandy soils. Regeneration occurs mostly through new shoots from plant roots. Seeds are spread by birds (chiefly song birds) and small mammals. Seed coats are scarified in passing through the digestive tracts of birds and mammals, and this may increase subsequent germination. However, this species is rarely abundant.

Growth and fruit production are best where limber honeysuckle is exposed to sunlight. On

sandy plains in association with blueberries it maintains itself but seldom replaces or hinders growth of the blueberries.

Uses

Deer, hares, and rabbits utilize the twigs of this plant. However, because of its scattered presence and low growth form, it is not used to any great extent by these species. The fruits are eaten by grouse, song birds, and small mammals, particularly rodents. Since the fruits set well, they provide food during late summer and early fall. However, this source of food cannot be considered important. Negligible cover is provided by limber honeysuckle because the plants usually are scattered and leaves drop early in the fall.

Propagation

Limber honeysuckle has been cultivated since 1636, but seeds or planting stock are seldom, if ever, available from state or commercial nurseries. I found little specific information about limber honeysuckle except that it and American fly honeysuckle may have little or no seed dormancy. More details are given in the discussion of American fly honeysuckle above.

Management

This species plays an unique role in a balanced ecosystem, but in itself cannot be considered important in wildlife management. Limber honeysuckle has established itself on blueberry barrens, in openings in the forest, and along roadsides. Apparently, loose soil, such as is found on sandy barrens and on disturbed road right-of-ways, favors germination of seeds. The plant usually maintains itself as long as other plants do not completely shade it out in the process of plant succession. Burning of blueberry barrens may or may not be of advantage in maintaining stands of limber honeysuckle. No management practice of this nature has been documented.

HAIRY HONEYSUCKLE

Habitat

The range of hairy honeysuckle is discontinuous. It is found in acid bogs and coniferous forests in the north; in moist areas of the Appalachian Mountains, including the Alleghenies, Catskills, and Adirondacks; and generally in cool, moist sites elsewhere throughout its range. In the southern portion of its range it is generally found at higher elevations. However, in the northern latitude of Quebec and Ontario it is found near sea level (*Dorothy Swales, personal communication*). Extremely cold temperatures and long periods of dormancy beneath deep snow apparently do not limit this species. It grows under winter temperature extremes of -5 to 10°F in the southern portion of its range and of -20 to -35°F in the north. It does not grow in areas of low rainfall or where precipitation is quickly dissipated.

Hairy honeysuckle usually grows in poorly drained acid soils underlain with clay, where plants are surrounded by moisture through most of the year.

Plant associates of hairy honeysuckle are red and black spruce, tamarack, white pine, balsam fir, black cherry, serviceberry, red maple, beaked hazel, heath plants, and viburnums. It has been observed growing in the shade of a northern white-cedar swamp (*Ralph Smith, personal communication*). Alders and willows may also grow in close association.

Life History

Flowering occurs in June and July, later in northern latitudes. The floral tube is 2 to 2.5 cm long, orange or yellow, and hairy. The fruit is a berry, which turns red when it ripens in mid to late August and early September.

This species is a sprawling and climbing shrub with winding, twisting branches that may twine around other plants nearby. This growth habit gives the leaves of the hairy honeysuckle an advantage in reaching for sunlight. Regeneration is by shoots springing up from the spreading roots and from seed dispersed by birds and small mammals. The

seeds germinate when deposited on wet acid soils.

Hairy honeysuckle is a strong competitor in its ecological niche. Its twining habit is advantageous even where there is severe crowding from heath plants. But, like American fly and mountain fly honeysuckle, it is common but not abundant in its habitat, and rarely increases to the point where it dominates a site.

Uses

Moose, deer, and snowshoe hares eat the twigs and foliage. However, because of the low growth form and the tendency to be covered by snow in winter months, use by deer and moose is generally slight. By contrast, hares live in close association with hairy honeysuckle; and use in winter may be moderate to heavy along edges of conifer swamps. Some use may be made of fruits by birds and small mammals, but this has not been documented. Hairy honeysuckle is too spreading in growth form and too scattered in its occurrence to provide good protective cover.

Propagation

This species has been cultivated since 1825, but is not available commercially. Some information given about propagation of American fly honeysuckle applies to this plant. Seed lots of hairy honeysuckle have shown both seed coat and embryo dormancy. Optimum seed treatment is unknown, but fair germination was obtained following warm/cold stratification in sand or peat for 60 days at 68 to 86°F (daily alternation) followed by 60 days at 41°F (*U. S. Forest Service 1948*).

Management

The species has established itself on a variety of soils in the Northeast, particularly on sandy plains and stream banks, and may have some limited potential in management for snowshoe hares. Stock from nurseries have been used for ornamental plantings, but plantings for wildlife have been negligible. The plants thrive and grow well when established in their preferred habitat, and would seldom require either maintenance or control.

SWAMP FLY HONEYSUCKLE

Habitat

This species is usually restricted to wet woodlands, bogs, swampy thickets, and roadsides in lowlands (*Fernald 1950*). It apparently grows best in moist acid soils and in full sunlight (*Van Dersal 1938*), but detailed habitat information is lacking. The most common associates probably are heath plants, viburnums, dogwoods, and wet-site conifers.

Life History

Flowering occurs from late in May to July, and the fruit ripens from late July to early September. Ripened berries usually are deep red in color and do not persist on the plants. Fruit production is light compared to that of Tatarian honeysuckle.

The plant is a small erect shrub, 2 to 5 feet tall. Regeneration is from root suckers and seeds dispersed by birds. This species commonly persists on wet sites but usually is not prolific.

Uses by Wildlife

Deer, hares, and cottontail rabbits browse swamp fly honeysuckle but the extent of this use and possible uses by birds and small mammals have not been documented. Due to its growth form, this species has only minor cover value for wildlife.

Propagation

Stock is not available commercially, but some of the information given for American fly honeysuckle applies. An exception is that seeds of this species apparently have both seed coat and embryo dormancy. Dual stratification has been used: 60 days at 68 to 86°F (or 50 to 77°F), followed by 90 days at 41°F. This pretreatment gave fair germination results in one sample (*U. S. Forest Service 1948*), but probably is not an optimal treatment. The number of cleaned seed per pound was 238,000 in one sample (*U. S. Forest Service 1948*).

Management

No management experience with this species has been documented. Its wildlife values probably do not justify specific management practices other than those that apply to associated species such as the heath plants, viburnums, dogwoods and willows.

MOUNTAIN FLY HONEYSUCKLE

Habitat

This species, including four varieties, is basically a subarctic plant that prefers cool, moist summer conditions and withstands winter temperature to --50F° and long dormancy periods beneath snow (*Dorothy Swales, personal communication*). Optimum conditions have not been determined, but none of the varieties ranges southward in the mountains beyond northeastern Pennsylvania.

Mountain fly honeysuckle occurs mostly on peaty acid soils in or near bogs or rocky barrens, but also grows on limestone-derived sandy and other soils (*Van Dersal 1938*). The sites are moist to well-drained and usually in full sunlight. Near the southern limits of the range, the plant usually occurs at high elevations near mountain ponds or bogs; it has been noted growing at 5,000 feet in elevation, above the timber line on Mt. Marcy in New York (*Ralph Smith, personal communication*). Farther north, in Canada, it grows at or near sea level in the taiga and along edges of the tundra.

This species almost always grows in association with heath plants, red or black spruce, tamarack, and balsam fir (*Greenleaf Chase, personal communication*).

Life History

Flowering occurs from late April to July, and the fruit—a blue berry—may ripen from early summer to August. Fruit production is

relatively scanty, but little or nothing has been documented about fruit productivity, seed characteristics, minimum bearing age, etc.

Mountain fly honeysuckle grows close to the ground, and seldom is over 1 to 2 feet tall. Its occurrence is usually scattered; new plants probably arise from seeds dispersed by small birds and microtine rodents. Root suckering probably accounts for most of the spread of established plants. Best growth is attained in full sunlight, but abundance is limited where evergreen heath plants dominate the site and shade the honeysuckle. This species is generally free from insect and disease attack (*Van Dersal 1938*).

Uses

Snowshoe hares, deer, and moose browse this species, but the low-growing plants are generally unavailable beneath the snow during winter. However, deer browse the plants heavily in the late winter and spring as the snow melts (*Ralph Smith, personal communication*). Plants will persist well even under heavy browsing by deer and hare. The fruits are edible for humans, and small rodents and song birds make use of them. Potential food value to wildlife is low because of the plant's scattered occurrence, unavailability during winter, and low fruit production. This species has little cover value except for small rodents.

Propagation

No specific information is available.

Management

Since this species grows in scattered remote areas and has fairly low value for wildlife, there is little justification for species management.

Established plants in the wild are self-maintaining. No management is being practiced on this species. Control is not necessary.

EASTERN HOPHORNBEAM

Ostrya virginiana (Mill.) K. Koch

Also called American Hophornbeam, Bois de Fer, Deerwood, Eastern Ironwood, Hornbeam, Ironwood, Leverwood, and Rough-Barked Ironwood.

By Tom S. Hamilton, Jr.

*University of Massachusetts
Amherst*

RANGE

Eastern hophornbeam reaches its northward limits within the Northeast, but extends far to the west and south. The range is Nova Scotia to Maine, southern Quebec and Ontario, northern Michigan and Minnesota, southern Manitoba, and eastern North Dakota, south to eastern Texas, northern Mexico, and northern Florida (*Little 1953*).

HABITAT

This species grows under most of the climatic conditions that occur in the Northeast, except in the coldest areas. Optimum conditions for growth have not been determined, but the largest specimens are in southern Arkansas and eastern Texas.

Annual precipitation in the range of hophornbeam varies from about 20 inches in the west to about 60 inches in the south, with an average of around 45 inches. In the north, precipitation is fairly well distributed throughout the year, while in the south the rainfall averages about 50 inches a year, with an average of 37 inches from March to September (*Shel-*

Jord 1963). Temperatures in the range of this species vary from an average in January of 0°F (northern Nebraska) to 60°F (northern Florida), and an average in July of 65°F (north) to 80°F (south) (*U. S. Forest Service 1965*). This species can be found at elevations of sea level to about 5,200 feet in the southern Appalachians.

Hophornbeam grows best on moist but well-drained, fairly fertile to rich soils, particularly in limestone regions. In New York and elsewhere, hophornbeam is a common invader of moister sites in old fields and often precedes or accompanies white pine (*Bump 1950, Hosely 1938*). However, the species is adaptable and occurs as a scattered understory plant in most of the forest types found in the Northeast (*U. S. Forest Service 1965*). Though it prefers moist, rich soils, hophornbeam grows in a wide variety of soil and moisture conditions. Associated understory species vary among forest types, but may include service-berry, American hornbeam, witch-hazel, maple-leaf viburnum, striped maple, red maple, pinxterbloom azalea, and blueberries (*Bump 1950, Kurmis 1970*).

LIFE HISTORY

Hophornbeam flowers in April to June in the Northeast. Flowers of both sexes occur on the same plant, but they are separated by being in different catkins. The male-flower catkins are about $\frac{1}{2}$ inch long, slender, pendulous, and naked during their first season and winter, often in twos or threes at the ends of the twigs, and scattered in the crown. They are 2 to $2\frac{1}{2}$ inches long and drooping when in bloom. The female-flower catkins are about $\frac{1}{4}$ inch long, upright, slender, in small open clusters at the ends of small leafy branches. Fertilization is by wind-borne pollen.

The fruit is a ribbed, spindle-shaped nutlet about $\frac{1}{4}$ inch long. It is enclosed by a bladder-like sac which is part of a slender-stalked, pendulous, hoplike cluster, about $2\frac{1}{2}$ inches long. Fruits ripen in August-October and occasionally persist into the winter. The hops are bright green in early autumn and light gray to greenish brown when ripe.

The hops dry and gradually fall apart soon after ripening, and are dispersed largely by the wind, but occasionally by birds (*U. S. Forest Service 1948*). Seed production per plant varies from year to year. The plants do not produce seed in quantity until about 25 years old.

Reproduction in the wild is mostly by seeds, which germinate in the first spring after seed fall. The mature plants are usually round-headed trees, to 20 to 30 feet in height, with a trunk 12 inches or less in diameter. The largest hophornbeams are in Arkansas and Texas; some are 60 to 70 feet tall, with trunks 18 to 24 inches in diameter.

This species is able to grow in dense shade and is usually an understory tree. It is a slow grower and not aggressive, and its ability to grow in shade makes it valuable for underplanting or retention in the shade of oaks and other large trees. Hophornbeam is fairly free from serious insect and disease pests (*Hepting 1971*). It is also highly resistant to damage by wind, snow, and ice, and the heartwood is durable in contact with the soil (*Hepting 1971*).

USE BY WILDLIFE

Hophornbeam is an important food of ruffed grouse, particularly in New York, Pennsylvania, and Wisconsin, but may be less important in New England and south of Pennsylvania. In winter, the buds and catkins of hophornbeam rank as food with those of aspen and birches, and with apple buds. Among various winter food habit studies of grouse, hophornbeam comprised 0 to 14.7 percent (average 3.9) by volume. The fruits are secondary foods in the fall, and the buds are primary foods in December to May (*Edminster 1947*).

Sharp-tailed grouse feed on hophornbeam in Michigan and elsewhere, and use it as a staple food in Quebec (*Van Dersal 1938*). Other species that eat hophornbeam fruit, buds, catkins, or twigs, mostly to a lesser degree than the grouse, include: ptarmigan, bobwhite, red, gray, and fox squirrel, deermouse, deer, cottontail, ring-necked pheasant, purple finch, rose-breasted grosbeak, and downy woodpecker (*Hosely 1938, Martin et al 1951*).

As food of cottontails, bark of hophornbeam ranked above the middle among 24 species of woody plants. Analysis of the bark, in percent, showed moisture 6.2, ash 5.2, crude protein 6.1, crude fiber 20.1, fat 3.7, and other non-determined extracts 58.7 (*Dalke and Sime 1941*).

Hophornbeam also provides some nesting or escape cover for small birds and mammals (*U. S. Forest Service 1948*).

PROPAGATION

Nursery-grown plants from 5 to 12 feet tall and $1\frac{1}{4}$ inch caliper were available recently from 10 nurseries in the United States, one in Canada, and one in England. Collected stock was available from three other nurseries, in sizes 5 to 10 feet tall and $1\frac{1}{2}$ to 4 inch caliper. Seed was available from at least one source in the United States (*LMIS 1966, Mattoon 1958*).

The fruits can be hand-picked in late summer or fall when they are pale greenish-brown but before they are dry enough to shatter. When fully ripe, the hops are greenish-brown to light gray. After drying, the hops can be

beaten or rubbed and the seed can be separated from the chaff by fanning. One bushel of fruit will yield approximately 2 pounds of seed; 100 pounds of fruit yields about 21 pounds of seed. Cleaned seeds average about 30,000 per pound. If necessary, cleaned and dried seed apparently can be stored at low temperatures for some time, but optimum storage conditions and viability have not been reported (*Swingle 1939, U. S. Forest Service 1948*).

Either fall or spring sowing of seed in well-prepared nursery beds is feasible. Fall sowing should be done in drills soon after the seed has been collected, preferably in early September. In one case seed was collected when slightly green in August and sown immediately. Germination was 100 percent the following spring (*Titus 1940*). Fall-sown beds should be mulched with burlap, straw, or similar material until germination begins in the spring. Then mulch should be removed.

To prepare for spring sowing, seed can be stored over winter in moist sand or peat at 41°F. However, a warm-plus-cold treatment may be better. Recommended treatments are 60 days at 68 to 86°F then 140 days at 41°, or 6½ months at 50 to 77° then 90 days at 41°. Limited tests of such treatments yielded germinative capacities of 27 and 65 percent (two tests) and potential germinations of 85 to 90 percent (*Sandahl 1941, U. S. Forest Service 1948*).

In the nursery, the stored seed should be sown as soon as the soil can be worked. The seedbed should have well-drained, loamy, mineral soil. Plant the seed ¼ inch deep in rows in open, sunny beds, firm the soil over the seed, mulch, and keep moist. Germination should take place during the same spring, but if it is irregular, cover the beds with leaf mold to prevent excessive drying during the summer. In the second year after germination, remove the seedlings from the bed and line them out in open nursery rows (*U. S. Forest Service 1948*).

Direct field planting of seed is not recommended, but the best natural seedbed would

be a moist, well-drained, loamy, mineral soil partially protected by vegetative cover.

Nursery-grown stock transplants fairly well, but it is important that some soil from the growing beds be moved with the plants to insure the symbiotic root-fungus association (*Shelford 1963*).

MANAGEMENT

This species may be most valuable in woodlands managed at least partly for grouse and the other wildlife named above. If hophornbeam is present, it should be retained except where it competes with plants having greater wildlife value. Being a highly shade-tolerant understory tree, hophornbeam is usually not a serious competitor with timber species (*Edminster 1947*). Light thinning of overstory trees may increase fruit production, but complete overstory removal would seldom be warranted.

Natural establishment of hophornbeam usually is from seed distributed by wind or birds. However, to establish the plant for wildlife use, the preferred method is to plant 2-foot high or taller stock in masses or groups in forest openings, woodland borders, or old fields. Since hophornbeam is disease-resistant and shade-tolerant, little or no maintenance would be needed.

Supplementing its wildlife value, hophornbeam merits consideration as an attractive, small-to-medium size, ornamental tree. The crown is usually round-headed, and the foliage and light-green-to-brown fruit are handsome in the fall.

Hophornbeam would seldom need to be controlled. It is moderately susceptible to herbicides such as D-T and 2,4,5-T applied as foliage sprays (*Egler 1949, Wendel 1966*).

MISCELLANY

Hophornbeam wood has home uses and some commercial value. The wood is strong, hard, tough, and durable, and is useful for fence posts or levers, wedges, tool handles, mallets, and similar small articles (*Grimm 1966*).

AMERICAN HORNBEAM

Carpinus caroliniana Walt.

Also called Blue Beech, Ironwood, Musclewood, and Water Beech.

By Robert W. Donohoe

*Ohio Department of Natural Resources
New Marshfield*

RANGE

This species occurs throughout the Northeast and southward to northern Florida, westward to eastern Texas, and northward to Minnesota and Ontario. It is most abundant and grows largest on the western slopes of the southern Allegheny Mountains and in southern Arkansas and east Texas (*Sargent 1922*).

HABITAT

American hornbeam is adapted to a wide variety of climates within the region. It occurs mainly on rich, moist soils in bottomlands, coves, and lower protected slopes and is common along the borders of streams and swamps (*Sargent 1922, U. S. Forest Service 1948*).

Three distinct forest types are recognized in the Region: (1) mixed mesophytic; (2) oak-chestnut; and (3) hemlock - white pine - northern hardwoods (*Braun 1950*).

The mixed mesophytic climax is a community in which the dominant canopy trees are beech, yellow-poplar, basswood, sugar maple, chestnut, sweet buckeye, red oak, white oak, and hemlock. To this list must be added the lower trees, which seldom or never attain canopy position. These include American horn-

beam, dogwood, the magnolias, striped maple, redbud, hophornbeam, holly, and service-berry (*Braun 1950*).

Chestnut oak, black oak, and red oak communities, or combinations of these, represent the former oak-chestnut forest type. The red oak community is the most mesophytic. Canopy trees associated with these communities include yellow-poplar, hickories, beech, sugar maple, white ash, and black cherry. Species of secondary importance in the understory are American hornbeam, flowering dogwood, sassafras, and hophornbeam (*Braun 1950*).

The hemlock - white pine - northern hardwoods forest type occupies the northern part of the region. The primary deciduous communities are sugar maple-beech-basswood, sugar maple-beech, and sugar maple-basswood (*Braun 1950*). American hornbeam occurs as an understory associate in these communities.

LIFE HISTORY

The male and female flowers occur separately, on different trees, and appear in April to early June. The fruits are ribbed nutlets, with bracts borne in catkins; and they ripen in

August to October (*U. S. Forest Service 1948*).

The nut is ovoid, somewhat flattened, ribbed and about 4 mm. long (*Britton 1908*). Numbers of cleaned seed per pound (7 samples) were: low 15,000; average 30,000; high, 45,000. Good seed crops are produced at 3- to 5-year intervals, with light intervening crops. The commercial seed-bearing stage is reached at about 15 years. Production is greatest at 25 to 50 years and probably ceases at about 75 years. Seeds are wind-blown only a short distance, and dispersal is mainly by birds (*U. S. Forest Service 1948*).

American hornbeam may attain a height of 30 to 50 feet and a trunk diameter of 18 inches or more. It has thin, very close and smooth bluish gray bark, often mottled with lighter or darker tints. In the south it is more abundant and attains its largest size. In the northern part of its range it is smaller, with a less symmetrical trunk (*Hough 1907*).

USE BY WILDLIFE

This tree is of secondary importance to wildlife. Ruffed grouse, ring-necked pheasant, and bobwhite quail eat small quantities of the seeds, buds, and catkins. The myrtle warbler eats some seeds; and small amounts of seeds, bark, and wood are eaten by rabbits, beavers, and fox and gray squirrels. White-tailed deer will browse the twigs and foliage (*Martin et al 1951*). American hornbeam has been reported in turkey crops from New York and Pennsylvania (*Korschgen 1967*).

PROPAGATION

Fruits of the American hornbeam should be collected by hand-picking from the tree in late summer or fall before they become dry. Pale greenish-brown color of bracts or involucre and light green-gray color of seeds indicate ripeness (*U. S. Forest Service 1948*).

Seeds collected slightly green may germinate promptly. In one trial, fresh seeds planted on August 19 all germinated the following spring. When gathered, the seeds were immature, just past the "milk stage" (*Titus 1940*).

Fruits that are not to be used for immediate

sowing should be spread out to dry and subsequently placed in a dewinging machine or beaten in bags to separate seed from the involucre (*U. S. Forest Service 1948*). Also, fruits can be cleaned with a Waring blender in which rubber has been substituted for the steel blades (*Coggeshell 1954*).

The seed can be separated from the chaff by screening and fanning, and stratified in a mixture of sand and peat for overwinter storage. For longer storage it should be sealed in containers soon after collection and stored at 35 to 45°F. (*U. S. Forest Service 1948*).

Seed dormancy may be broken by stratification for 100 to 120 days at 35 to 45°F. in sand or peat, or preferably in a mixture of the two. Sowing may be done in fall or spring. If in fall, seeding should be done in well-prepared beds soon after collection, the seed being covered approximately $\frac{1}{4}$ inch deep with firm soil. Beds should be mulched with burlap, straw, or other material held in place until after the last spring frost. Drills 8 to 12 inches apart are preferred to broadcast sowing. In the spring, stratified seed should be used. Surface soil should be kept moist until after germination, and partial shade is recommended until after seedling establishment (*U. S. Forest Service 1948*).

The optimum natural seedbed for American hornbeam is continuously moist, rich, loamy soil protected from extreme atmospheric changes. Germination occurs from April to June in the spring following seed maturity (*U. S. Forest Service 1948*). Information about seeding in the field is lacking. However, the procedures recommended for nursery use suggest field methods.

MANAGEMENT

Overstory cover is apparently important for the maintenance of American hornbeam. Cutting practices in areas where the trees occur should leave some of the canopy trees for shading purposes.

American hornbeam may be controlled by an application of 2,4,5-T at a concentration of 4 pounds acid equivalent per 100 gallons, diluted in oil. The herbicide may be applied in frills, girdles, or gashes at all seasons of the year (*Rudolf and Watt 1956*).

MISCELLANY

American hornbeam is usually regarded as a weed tree because of its small size and poor form (*Harlow and Harrar 1958*). The tree is of slow growth but very ornamental; its leaves turn orange and scarlet in the autumn. The wood is dense, hard, and very difficult to work

(*Britton 1908*). It is of commercial value for making handles, mallets, and golf-club heads (*U. S. Forest Service 1948*). The nuts are edible by humans, but they are so very small, rarely $\frac{1}{8}$ -inch long, that only in emergency would they be gathered for food (*Fernald and Kinsey 1943*).

HUCKLEBERRIES

BLACK HUCKLEBERRY, *Gaylussacia baccata* (Wang.) K. Koch.
Also called Gueules Noires.

DANGLEBERRY, *Gaylussacia frondosa* (L.) T. & G.
Also called Bluetangle.

BOX HUCKLEBERRY, *Gaylussacia brachycera* (Michx.) Gray.

DWARF HUCKLEBERRY, *Gaylussacia dumosa* (Andr.) T. & G.

By William M. Healy
*Northeastern Forest Experiment
Station
Morgantown, West Virginia*

and

Sadie L. Robinette
*West Virginia University
Morgantown*

RANGE

Black huckleberry is the most important huckleberry growing in the Northeast, and the only one found in all parts of the region. It occurs from Newfoundland to Saskatchewan and south to Georgia, Alabama, Kentucky, and Illinois. Dangleberry grows on Coastal Plain sands from New Hampshire to Florida and occurs inland as far as Ohio, West Virginia, and Tennessee. Where their ranges overlap, dangleberry and black huckleberry usually grow together and respond similarly to forest management.

Two other huckleberries may be encountered. Box huckleberry grows in isolated colonies on dry sites in Maryland, Delaware, West Virginia, Tennessee, and Kentucky. Dwarf huckleberry is restricted to wet, sandy soil and hogs on the Coastal Plain from Newfoundland to Florida (Gleason 1963c).

HABITAT

Black huckleberry is hardy throughout the region, but we found no information about the optimum climatic conditions for the huckleberries.

The habitat of black huckleberry and dangleberry is characterized by soil that is acidic, coarse-textured, and low in nutrients. The sites are usually dry, either because of the coarse soils or because they are in exposed positions (Reiners 1965). Acid soil seems to be essential; huckleberries planted in neutral or basic soil fail to grow (Wherry 1957). Black huckleberry grows best in soil with a pH of 4.0 to 5.0, while 4.5 to 6.0 is optimum for dangleberry (Spurway 1941).

Black huckleberry, lowbush blueberry (*Vaccinium angustifolium* Ait.) and early sweet blueberry (*V. vacillans* Torr.) often form a dominant shrub community on Coastal Plain

sands in New Jersey, New York, and New England (*Reiners 1965*); on sandstone ridges in Connecticut, New York, Pennsylvania, and western Maryland (*Nichols 1914*); and on sandy and peaty soils of the Lake States (*Hosley 1938*) and other similar habitats in the Northeast (*Reiners 1965*). This huckleberry-blueberry community occurs both in openings and beneath forest stands. It often starts as a pioneer or early successional stage and then persists as the forest develops on dry sites. The timber stands that overtop huckleberries characteristically have thin, open canopies (*Reiners 1965*).

It is not known if huckleberries are restricted to dry sites because of moisture relations, or because trees on dry sites produce canopies that considerable light penetrates (*Reiners 1965*). Oak-hickory, chestnut-oak, oak-pine and pine-scrub oak are the common forest types that have a huckleberry-blueberry shrub layer; and the dominant trees are pignut and shagbark hickories, white, scarlet, chestnut, and black oaks, and pitch and shortleaf pines (*Brayton and Woodwell 1966, Nichols 1914, Reiners 1965, Stephenson 1965*). Next to the blueberries, bear oak is probably the most common shrub associate of huckleberry. In openings, huckleberry grows with sweetfern, chokecherry, smooth sumac and shining sumac; and in oak-hickory stands, flowering dogwood, eastern hophornbeam, teaberry, mountain-laurel, and rhododendron are frequent associates. Dangleberry is a common associate but rarely a dominant shrub in the huckleberry-blueberry community on Coastal Plain sands.

Huckleberry-blueberry stands often develop after burning. Both shrubs sprout readily in response to fire, and thrive if burning is neither frequent nor severe (*Brayton and Woodwell 1966*). Controlled burning in the New Jersey Pine Barrens at 3-year intervals reduced shrub cover by one-half, but the relative importance of early sweet blueberry increased while black huckleberry and dangleberry decreased (*Buell and Cantlon 1953*). In general, burning more than once every 5 years favors early sweet blueberry over black huckleberry and dangleberry (*Brayton and Woodwell 1966*). Protection from fire for a

decade resulted in a decrease in density of the shrub layer in some oak-pine communities in the New Jersey Pine Barrens. Like most shrubs, black huckleberry decreased in density, but it increased in relative importance over early sweet blueberry. Dangleberry decreased significantly (*Stephenson 1965*).

LIFE HISTORY

Specific life-history information was found only for black huckleberry. Leaf bud-break and flowering both begin about the first week of May, slightly later than the blueberries. The flowers last through June, and the berries mature by the end of July. The berry is black and contains 10 seeds, each about 1/16 inch long. Huckleberries remain on the plants from July to September, but ruffed grouse stomach records commonly show seeds through November (*Hosley 1938*). The many birds and mammals that eat huckleberries probably are responsible for the dissemination of seeds, but the effect of passage through their digestive tracts is not known (*Reiners 1965*).

Insects pollinate the flowers. Despite large fruit crops, seedlings are rare. New colonies are established from seed, but reproduction and spread of existing colonies is almost entirely through growth of the root system. Slender branched roots grow in all directions from the main roots. These occasionally produce aerial shoots, and injuries to the root system or destruction of above-ground stems will stimulate sprouting from the roots (*Reiners 1965*).

In the Pine Barrens of Long Island, New York, 1-year-old black huckleberry stems were unbranched and up to 7.8 inches tall. As they grew older, the stems produced many side branches. The result was a dense, twiggy canopy 12 to 39 inches tall, depending on site conditions. Ring counts revealed an average stem age of 5.7 years and a maximum age of 15 years (*Reiners 1965*). Fruit production begins when stems are 3 years old (*Spinner and Ostrom 1945*).

Black huckleberry is intermediate in tolerance to shading (*Davidson 1966, Hosley 1938*). Partial cuttings of the overstory usually favor huckleberry, but competition from other shrubs may be as important as

overhead shade. In one experiment in the Pine Barrens of New Jersey, black huckleberry decreased while blueberry and other shrubs increased after removal of overstory oaks (*Buell and Cantlon 1953*).

In unburned stands, black huckleberry usually overtops lowbush blueberry, but it generally does not completely overtop early sweet blueberry (*Reiners 1965*).

USE BY WILDLIFE

The huckleberries are important for cover, for fruit, and for browse production. Together with the blueberries and bear oak, black huckleberry provides low cover for song birds and small mammals over extensive areas of dry open woodland in the Northeast. Its food value is largely restricted to the fruits, but it provides some browse. The fruits ripen in summer along with the blueberries, and in general, wildlife and humans prefer the less seedy blueberries to the huckleberries.

Black huckleberry and dangleberry fruits are eaten by sharp-tailed grouse, greater prairie chicken, bobwhite quail, wild turkey, mourning dove (*Van Dersal 1938*), and at least 7 song birds, including the catbird and scarlet tanager (*Martin et al 1951*). The Ruffed grouse eats the fruit in summer and buds in winter, but black huckleberry is a food of secondary importance (*Brown 1946, Edminster 1947, Hosley 1938*). White-tailed deer and cottontail rabbits browse huckleberry stems lightly in most of the Northeast (*Martin et al 1951, Trippensee 1938, Van Dersal 1938*), but occasionally cottontails severely damage black huckleberry stems during winter (*Sweetman 1949*). The black bear, gray fox, and fox squirrel also eat huckleberry and dangleberry fruits (*Hosley 1938, Martin et al 1951*).

PROPAGATION

Nursery manuals usually treat huckleberries as a genus and state that they are propagated in the same way as blueberries (*Bailey 1950:317, Laurie and Chadwick 1931, Sheat 1953*). The usual methods of propagation are: (1) from seed sown under glass in winter or spring, (2) from hardwood and softwood cuttings, (3) by division in fall and spring, and

(4) by layering in spring and summer. The vegetative methods are the same for all species.

Specific information about propagation from seed was found only for black huckleberry. Seeds can be obtained by harvesting ripe fruit with a blueberry rake and extracting the seed by macerating the berries in water and floating off the pulp. Sound seed will settle to the bottom. Yields were approximately 3 pounds of cleaned seed per 100 pounds of fruit, and the number of cleaned seed per pound ranged from 281,700 to 412,000 (*Swingle 1939, U. S. Forest Service 1948*). Seed has been air-dried and stored in sealed bottles at 41°F for 2 years without loss in viability (*U. S. Forest Service 1948*).

Cleaned seed should be sown in an acidic mixture of sand and peat. In one study, good germination was obtained with seed that had been stratified for 30 days at temperatures alternating diurnally from 68 to 86°F and then held at 50°F. Germination began between 8 and 27 days and was complete by the 47th day after the start of the 50°F stratification (*U. S. Forest Service 1948*).

Although we found a statement that all huckleberries can be propagated from seed sown under glass in winter or spring (*Van Dersal 1938:135*), we also found an indication that box huckleberry clones may be self-sterile (*Coville 1919, Wherry 1934*). About 90 percent of the seeds from one isolated box huckleberry clone were empty shells. Only 3 seeds germinated from 1,600 sown in November on a suitable soil of peat and sand. July plantings also gave poor results, and the author believed that individual plants were sterile to their own pollen (*Coville 1919*). Because box huckleberry usually occurs as a clone, it is a good idea to test seed sources for germination before attempting nursery production.

MANAGEMENT

Black huckleberry will often be managed as part of a huckleberry-blueberry shrub community. Light burning in the spring at 2- or 3-year intervals will favor blueberries, while burning at intervals of 5 years or longer will favor huckleberry. Complete removal of the overstory will increase the relative importance

of blueberries, but partial cuttings usually favor huckleberry (*Buell and Cantlon 1953, Stephenson 1965*).

Huckleberry clones can be rejuvenated by removal of competing vegetation, light burning, or shallow cultivation and cutting back the tops of the plants. Stands can be enlarged by removing encroaching vegetation and then lightly cultivating or layering the plants at the edge of the stand.

Black huckleberry is useful for erosion con-

trol because it grows on sterile acid soils, which often present planting problems (*McAtee 1936*). Its attractive foliage, flowers, fruit, and low growth form make it suitable for ornamental plantings. Box huckleberry has also been recommended as an ornamental ground cover. It has attractive evergreen foliage, usually grows only 6 to 12 inches tall, and thrives in the shade (*Curtis and Wyman 1933*).

MAPLES

MOUNTAIN MAPLE, *Acer spicatum* Lam. Also called Low Maple, Moose Maple, and Water Maple.

By Paul E. Hosier

Department of Botany, Duke University
Durham, North Carolina

RANGE

Mountain maple is found in all the north-eastern states and provinces. It occurs from Newfoundland to Saskatchewan, south to Connecticut, Ohio, Michigan, and northern Iowa, and in the mountains to western North Carolina and eastern Tennessee (*Gleason 1963b*).

HABITAT

Mountain maple thrives in a humid climate that has adequate precipitation in all seasons. The snow-cover period ranges from about 30 days in the southern part of the range to more than 120 days in the extreme northern part. The growing season lasts from less than 120 days to more than 170 days (*Van Dersal 1938*). The average January temperatures range from 0 to 40°F., and the average July temperatures range from 60 to 75°F. within the range of the species. Extreme temperatures in its range are -50 and 105°F. The precipitation average varies from about 25 to 60 inches (*U. S. Department of Agriculture 1941*).

Mountain maple has medium moisture and nutrient requirements and low heat and light requirements (*Bakuzis and Hansen 1959*, *Krefting et al 1966*). In the north, it prefers

rich soils on moist rocky slopes and flats and along streams (*Vincent 1965*) but grows well in drier or well-drained acid soils (*Van Dersal 1938*). In the Appalachians it is widely distributed and locally common at 2,500 to 4,200 feet in elevation (*Van Dersal 1938*).

Mountain maple is a prominent understory tree of the maple-beech-basswood forest, the birch-hemlock-spruce forest, and the northern conifer types (*Shelford 1963*). It is a member of the mixed mesophytic type at higher elevations of the Appalachians and the red oak-birch and red oak-basswood forest of the mountains of Pennsylvania. It is also found in the beech-maple forest of the Great Lakes area and the hemlock-white pine-northern hardwoods forest (*Braun 1950*).

LIFE HISTORY

Mountain maple flowers from May till June (*U. S. Forest Service 1948*). After the leaves are fully grown, the flowers are produced in a narrow, erect, long-stalked, terminal cluster. The male flowers are borne near the tip of the cluster, the female flowers near the base. The fruit is a double samara about ½-inch long (*Palmer 1919*). The seeds ripen between mid-September and mid-October.

No data were found about the quantity of

seed produced per tree. Wind is the primary factor in spreading the seeds. Stems of seedling origin are rare, suggesting that seedling mortality is high under natural conditions (Krefting et al 1966).

Mountain maple attains a maximum height of 30 feet in the Appalachian Mountains, but tends to be smaller, about 20 feet, in the north. The tree has a short bole, which may become 6 to 8 inches in diameter in the south but seldom exceeds 3 to 4 inches in the north. It commonly forms clumps, each member having several upright branches, which produce many branchlets and form a bushy head (Harrar and Harrar 1946). Reproduction is most commonly by sprouting from the stem, including stems growing laterally underground, or from layering of branches in contact with the ground. Seedling reproduction is usually scarce and root suckers may be rare (Post 1965, Post 1969, Vincent 1965). The stems produce buds that tend to remain dormant until they are disturbed by cutting or browsing (Krefting et al 1966).

In Ontario and New Brunswick, senile mountain maples (40 to 50 years old) produced more new vegetative growth than younger plants. This suggested that a factor inhibiting growth is present in living stems but disappears as they approach death (Vincent 1965).

Height growth averaged about 1 foot per year, and the most rapid growth was from 5 to 10 years. Shoots from the lower portion of parent stems grew faster than other types of shoots. Stand densities were as high as 40 square feet of basal area per acre. Heights of the tallest stems did not seem to be related to age or origin (Vincent 1965).

Mountain maple can grow in either sunlight or shade, but grows best if neither is extreme. It is able to tolerate strong sunlight better than striped maple (Palmer 1949) and is about equal to balsam fir and red spruce in light requirements (Post 1969). Successionally, it usually comes in after openings in the overstory of the forest are produced. In virgin forest tracts, it has been known, along with striped maple, to form a distinct understory in the forest (Braun 1950). When released, by logging or other means, mountain maple may

dominate the site within 5 to 10 years and may suppress competing species, particularly spruce and balsam fir, for at least 35 years (Vincent 1965).

USE BY WILDLIFE

Deer and moose browse the bark and twigs of mountain maple, and beavers utilize the bark, particularly where aspen is lacking. Cottontail rabbits also browse on the plant (Van Dersal 1938). The buds are eaten by ruffed grouse (Peattie 1950).

PROPAGATION

The ripe seed of mountain maple may be collected from standing trees or gleaned from trees felled in logging operations (U. S. Forest Service 1948). The seeds, as well as seedlings, may be available commercially (Mattoon 1958). I found no information about the minimum seed-bearing age for mountain maple. Commercial seed was 93 percent pure and had a soundness average of 73 percent (range 57 to 84). The number of cleaned seeds per pound varied from 15,300 to 27,800, with an average of 22,000 (U. S. Forest Service 1948).

In nursery practice, seeds can be sown in either fall or spring. For sowing shortly after seed collection, the seeds should be pretreated by soaking in water, changed daily, for a week (Heit 1968). For spring sowing, the seeds should be scarified and stratified over winter. Since the samara husk and the seed coat act to delay germination, the husk should be removed and the seed coat should be scratched. Seeds should then be stratified in sand at 41°F. for 90 to 120 days. Data on germination are meager, but suggest that nearly all germination occurs within a month and that germinative capacity may be as low as 0 to 34 percent (U. S. Forest Service 1948).

Seeds that have been air-dried can be stored at low temperatures (41°F.) in sealed containers, but they do not store as well as seed of most other maples. Mountain maple seed lots stored for 2 years lost three-quarters of their original germinative capacity (U. S. Forest Service 1948). Some seed lots stored fresh (immediately after collection) germinated 1

year later in sealed containers in a 35°F. cold-room (*MacArthur and Fraser 1963*).

The seed should be sown about ¼ to 1 inch deep in mulch beds and sown either in drills or by broadcasting. For best growth the seedbeds should be shaded. One-year-old seedlings are usually large enough for outplanting (*U. S. Forest Service 1948*).

For propagating mountain maple vegetatively, layering may be practical, but use of cuttings apparently is not. Root and shoot cuttings tested in New Brunswick yielded less than 1 percent success. Fresh root and stem cuttings were planted weekly in an outdoor nursery during April-November. Recent-growth stem cuttings were dipped in a commercial hormone preparation and planted in vermiculite. Also, roots were severed from the stem and left in place. None of these treatments was effective (*Post 1969*).

Layering is common in the wild, and layering methods seem promising for artificial propagation. For example, a mountain maple that had been tipped by a bulldozer so that its crown was pressed tightly on the ground produced nearly 50 vigorous shoots, some of which grew 13 inches during the first year (*Post 1969*). I found no reference to intentional propagation by layering.

MANAGEMENT

Mountain maple is one of the most nutritious and palatable browse plants for deer. It withstands repeated and heavy browsing and actually produces the most browse when about 80 percent of the annual twig growth is re-

moved each year. If not heavily browsed, it often grows out of the reach of deer within 3 years (*Aldous 1952, Krefting et al 1966*).

In Minnesota, Krefting compared several top-killing treatments for stimulating regrowth. Cutting the stems with an ax near ground level during the dormant season was most effective. The second best treatment was breast-height spraying of the bark, until runoff, with 2,4-D (at least 12 pounds of acid per 100 gallons of No. 1 diesel oil). Spring treatment, at early bud-burst time, yielded more regrowth than fall spraying. Deer readily browsed the regrowth. Costs of cutting and spraying were about equal, but cutting produced more regrowth and had the added advantage of making much of the cut browse immediately available to deer (*Krefting et al 1966*).

Bulldozing can be used to either stimulate new growth in an aging stand or for eradication. If eradication is desired, the plants should be uprooted or the stems should be severed, or both (*Post 1969*). This treatment was considered less expensive than herbicides applied to the soil. If stimulation of new growth is desired, the plants should be tipped and the crowns mashed down, but complete uprooting and severing of main stems should be avoided.

Burning can be used to suppress mountain maple. After logging, slash should be piled on the maple thickets and burned. Where the thickets are scattered or are on rocky slopes, this treatment may be cheaper than bulldozing (*Post 1965*).

STRIPED MAPLE

STRIPED MAPLE, *Acer pensylvanicum* L. Also called Goose-foot Maple, Maleberry, Moosewood, Northern Maple, Striped Dogwood, and Whistlewood.

By Paul E. Hosier

*Department of Botany, Duke University
Durham, North Carolina*

RANGE

This species is found throughout most of the Northeast, from Nova Scotia and the Gaspé Peninsula to Ontario and central Michigan, from New England south to Ohio and Pennsylvania and in the mountains to northern Georgia (*Little 1953*).

HABITAT

Striped maple grows in regions that are relatively humid and provide frequent precipitation during all seasons. The frost-free period ranges from less than 100 days in the northern part of the range to nearly 200 days at the southern limit. The number of days of snow cover ranges from 120 to 60 days, north to south (*Van Dersal 1938*).

This species prefers acid soils (*Wherry 1957*); however no information was found to establish its pH tolerance range or the optimum pH. It prefers sandy loam soils that are moist but well drained (*Van Dersal 1938*). The tree grows well on rocky and exposed mountain slopes and on rock slides that are more or less soil-covered (*Braun 1950*). In the southern Appalachians, striped maple prospers up to 4,500 feet in altitude on south-facing slopes and is common from 2,500 to 4,200 feet

in the mountains of West Virginia (*Shelford 1963*).

Striped maple is considered an understory tree because it rarely attains the height of a canopy tree. In virgin forest tracts, striped and mountain maple may form a distinct low layer of vegetation (*Braun 1950*). Striped maple is associated with these forest types: maple-beech-basswood, birch-hemlock-spruce, mixed mesophytic, oak-chestnut, and hemlock-white pine-northern hardwoods (*Shelford 1963*).

LIFE HISTORY

Individual striped maples usually bear two kinds of flowers: some bi-sexual and others male only. The bright yellow flowers are borne singly on a drooping terminal cluster. Each cluster is usually either wholly male or bi-sexual. Flowers bloom from May to mid-June (*Palmer 1949*). The seeds ripen between September and mid-October and are disseminated in October and November (*U. S. Forest Service 1948*). The agent of natural dissemination is wind.

Mature trees may attain a height of 30 to 40 feet and a diameter of 8 to 10 inches (*Harvar and Harvar 1945*). Striped maple does not grow best in strong sunlight. It prefers the

shade of other trees, but will show a rapid increase in height if it has been densely shaded and then released by overstory thinning. However, if the sunlight is too strong, striped maple may be replaced by mountain maple where the latter species is established.

USE BY WILDLIFE

In winter, the twigs are consumed by white-tailed deer, ruffed grouse, and moose; and porcupines eat the bark. In summer, the leaves are eaten by moose and deer. Squirrels, chipmunks, and ruffed grouse eat the seeds (*Martin et al 1951; Bump et al 1947*). When aspen is lacking, beavers forage upon striped maple. Cottontail rabbits also eat striped maple (*Van Dersal 1938*). Several species of birds use the seed stalks and the leaves for nesting material (*Martin et al 1951*).

PROPAGATION

The seed or seedling stock of this species is not usually available from commercial growers. Seed may be collected from standing trees or taken from the branches soon after the trees are felled. Studies have established the soundness of commercial seed at 79 to 95 per-

cent. The number of cleaned seeds per pound varies from 9,700 to 15,600, with an average yield of 11,500 seeds per pound. Seeds can be stored moist in sealed containers at 41°F. for at least 18 months (*U. S. Forest Service 1948*).

In the nursery, the seeds are usually sown in the fall in mulchbeds to effect stratification. Most germination takes place early in the spring; however, some germination may be delayed because of dormant embryos. Growth of the seedlings is enhanced by shading the mulched beds.

The seeds can be stratified artificially by placing them in moist sand at 41°F. for 90 to 120 days. The stratified seed is then sown in the spring, $\frac{1}{4}$ inch to 1 inch deep. Within a few weeks, the seeds germinate. Germination experiments show 40 to 80 percent germination. The seedlings are relatively free of insect or fungus diseases (*U. S. Forest Service 1948*).

I found no literature about field propagation of striped maple.

MANAGEMENT

I found no literature specifically about management of striped maple.

MOUNTAIN-ASHES

AMERICAN MOUNTAIN-ASH, *Sorbus americana* Marsh. (*Pyrus a.* (Marsh.) D.C.) Also called American Mountainash, American Rowan Tree, American Service Tree, Dogberry, Indian Mozemize, Life-of-Man, Masse-Misse, Missy-Massy, Missey-Moosey, Mountain Ash, Mountain Sumach, Quick Beam, Round Tree, Roundwood, Service Tree, Small Fruited Mountain Ash, Wild Ashe, Wine Tree, and Witchwood.

SHOWY MOUNTAIN-ASH, *Sorbus decora* (Sarg.) Schneid. (*Pyrus d.* (Sarg.) Hyland) Also called Large Fruited Mountain-Ash and Roundwood.

EUROPEAN MOUNTAIN-ASH, *Sorbus aucuparia* L. (*Pyrus a.* (L.) Gaertn.) Also called Rowan-Tree.

By Steve Eabry

*New York Department of Environmental Conservation
Delmar*

RANGE

These are all northern forms; their occurrence in the southern parts of their ranges is spotty—mostly at cold, wet, rocky sites. American mountain-ash occurs in all states and provinces of the Northeast. Showy mountain-ash occurs in all the provinces, Newfoundland to Ontario, and south into the northern states, Maine to Northern Indiana. The naturalized range of European mountain-ash is similar to that of showy mountain-ash but extends a little farther south (*Gleason 1963b*).

HABITAT

These mountain-ashes occur naturally in a north temperate climate. Warm temperatures probably limit all three species. They prefer

moist situations, although they are also found on elevated slopes. American mountain-ash is found near sea level in southern Greenland (*Shelford 1963*) and at elevations of 6,000 feet in North Carolina (*Sargent 1922*).

The mountain-ashes grow best on rich, moist soil; but they also prosper at higher elevations on relatively poor sites with thin soil and on rocky areas (*Braun 1950*). The optimum pH range for American mountain-ash has been reported as 4.5 to 6.5 (*Spector 1956*) and 4.5 to 5.5 (*Spurway 1941*). Soil samples collected throughout Wisconsin from areas supporting vigorous fruit-bearing American mountain-ash had an average pH of 4.9 ± 0.09 , but soils in the 4.7 to 6.0 pH range were recommended for planting (*Wilde 1946*). European mountain-ash prefers a pH between 5.5

and 7.5 (Spector 1956). Soils saturated for more than a day or two seem to be harmful to seedlings (Lawyer 1968).

All three mountain-ashes are shrubs of climax and subclimax northern coniferous forest communities, along with speckled alder, Labrador tea, mountain and red maples, yellow birch, and bunchberry. American mountain-ash is also found in shrub types of the Appalachian mountains with mountain laurel, rhododendrons, blueberries, greenbriers, balsam fir, and yellow birch (Shelford 1963).

LIFE HISTORY

All species have flattened clusters of white flowers. Flowering occurs from May to July, after the plant is fully leaved. The fruits of the European and showy mountain-ashes ripen in August or September; those of the American mountain-ash ripen a little later, some into October (*U. S. Forest Service 1948*). The bright red, berrylike fruits of showy mountain-ash are 7 to 10 mm across, European 8 mm, and American 4 to 6 mm (Rehder 1940). Fruits are usually two- to five-celled with one or two seeds in each cell (*U. S. Forest Service 1948*).

Information about seed production by American and showy mountain-ashes is lacking. European mountain-ash seed crops are variable; in yearly measurements of five plants at the Kellogg Forest in Michigan, yields ranged from 0 to 0.36 pounds of fruit per square foot of crown, with a mean for 8 years of 0.14 pounds (Gysel and Lemmien 1964).

There have been no studies to determine if there are climatic races in American or showy mountain-ash, but races probably have developed in the native trees of Europe (*U. S. Forest Service 1948*).

Natural seed dispersal is chiefly by birds, with a little help from small mammals. The mountain-ashes reproduce mainly from seed. They usually will not grow from cuttings. Layering is difficult and often yields poor results. However, they graft easily (Lawyer 1968).

American mountain-ash has a relatively rapid growth rate, reaching an average height of 25 to 30 feet (Spector 1956). It starts growing early (mid-April in Massachusetts) and continues to early August, with 90 per-

cent of the growth occurring during 39 days from 1 May to 9 June (Kozlowski and Ward 1957). European mountain-ash has a moderate growth rate and reaches 20 to 40 feet (Spector 1956). It starts bearing fruit at about 15 years (*U. S. Forest Service 1948*), and may live about 80 years (Spector 1956).

The mountain-ashes are intermediate in shade tolerance (Spector 1956), sometimes growing under a fairly dense forest canopy, but more often in openings. Except on an ideal site, seedlings probably cannot compete with a dense herbaceous growth. Even 8-inch nursery stock all but failed when planted in sod on poor soil (Cook and Edminster 1944).

USE BY WILDLIFE

In Wisconsin, deer ate the leaves and tips from American mountain-ash in spring and summer, and browsed it in the fall. It was classed along with 7 other species as first choice in a palatability rating of 32 winter deer browse species (Dahlberg and Guettinger 1956). Mountain-ash is rated as a deer food "... species in short supply but generally accepted as preferred ..." in New Hampshire (Laramie 1968) and also in Wisconsin (Beals et al 1960). In Newfoundland, American mountain-ash was browsed by both moose and snowshoe hare, and was a favored food of both (Dodds 1960). It was sufficiently attractive to cottontails in Massachusetts to suffer considerable injury during the winter months (Sweetman 1944). American mountain-ash berries were the sixth most common food of spruce grouse in Ontario before the first snow. However, the berries did not occur in any of the 37 crops collected after the first snow (Crichton 1963). Ruffed grouse and songbirds, especially evening and pine grosbeaks, and cedar waxwings, are regular feeders on mountain-ash berries (Martin et al 1951). Showy mountain-ash fruits in the Albany, N. Y., area are eaten by starlings and robins as soon as the fruits start to color and soften. There are usually no fruits remaining by 1 September (Ralph Smith, personal communication). These birds usually consume all the mountain-ash fruits by early fall at the Arnold Arboretum (Fordham 1967).

Mountain-ashes are not particularly valua-

ble as wildlife cover except where they and associated species form thickets.

PROPAGATION

Seeds of these three mountain-ashes are normally available from at least three commercial sources (in Massachusetts, New York, and Pennsylvania), and plants are available from many nurseries. Addresses can be obtained from the Soil Conservation Service (1971).

Fruits may be picked in the field as soon as ripe and run either through a macerator to remove the pulp or through a fruit press. In the latter process, the fruit should be dried and the seed can be broken out by hand as it is sown. Fruits may also simply be spread out to dry and used in that form (*U. S. Forest Service 1948*).

The yield of seed per bushel of fruits was: American 1 to 2 pounds, European 3 to 7 pounds, and showy mountain-ash unknown. The number of cleaned seeds per pound is also variable. The following figures have been reported for American mountain-ash: an average of 160,000 (*U. S. Forest Service 1948*), 83,000 to 100,000 (*Van Dersal 1938*) and 83,500, 160,640, and 236,300 from three sources (*Swingle 1939*). The number of clean European mountain-ash seeds per pound has been given as about 104,000 (*Swingle 1939*, *Van Dersal 1938*) and as an average of 130,000 (*U. S. Forest Service 1948*). Showy mountain-ash averages 127,000 clean seeds per pound (*U. S. Forest Service 1948*).

Storage of European and American mountain-ash seeds at ordinary room conditions is usually satisfactory in either sealed or open containers, but temperatures below 70°F and about 25 percent relative humidity are recommended. Storage information for showy mountain-ash is lacking.

Mountain-ash seeds exhibit embryo and seed-coat dormancy. Untreated fruit or seeds sown in late fall or winter usually do not germinate until the second or third spring (*U. S. Forest Service 1948*). Germination can be hastened by cleaning the seed and sowing in late September (or by October 15 at the latest), or by spring sowing after stratifying the seed in

moist sand for 90 days at 68 to 86°F, then for 90 days at 41°F (*Heit 1967c*, *Heit 1968*, *U. S. Forest Service 1948*). Seed may be sown broadcast or in drills and should be lightly covered with about 1/16 inch of soil.

The yield of usable plants per pound of seed in one study was 225 for American mountain-ash and 2,090 for European mountain-ash (*Bennett 1939*). In another study, about 5,000 usable plants (species not reported) were obtained per pound of clean seed when seed was sown at the rate of 6 to 8 ounces per 100 square foot of seedbed. The best growing density was 20 plants per square foot (*Bump et al 1947*).

In nurseries, the mountain-ashes "like lime" and seem to deplete the seedbeds by taking unknown growth factors from the soil (*Lawyer 1968*). The seedlings are quite hardy and resistant to insects or diseases. However, they are attractive foods of deer and snowshoe hare, and may have to be protected where the chance of browsing is high. For field planting, 1-1 stock is best, but 2-0 is often suitable. Best results are obtained by planting on cool, moist sites. Natural seedlings are most common near the parent tree, on exposed mineral soil, and where some protective shade is available (*U. S. Forest Service 1948*).

Seedlings grown in the shade or crowded in the seedbed often develop thin bark. When planted they should be shaded to prevent damage from sunburn (*Lawyer 1968*).

MANAGEMENT

Need for care in selecting planting sites and protecting the seedlings from browsing was shown in a New York study (*Cook and Edminster 1944*). European and American mountain-ash seedlings about 8 inches tall were planted in poorly drained, sterile, generally acid soils on abandoned farmland. After 3 years, the highest survival (50 to 75 percent) was on land plowed before planting. Survival on scalped land was 30 to 70 percent, and for those planted in slits in the sod, survival was less than 10 percent. Both species grew feebly, scarcely maintaining their initial height. Twenty years after planting, the mountain-ashes had become smaller because of deer

browsing, and Smith (1964) concluded that the "... susceptibility of both to stem borers makes them poor materials for wildlife plantings." Although stem-borers may kill the shoots of mountain-ashes that are growing slowly, the plants often recover by sprouting (Ralph Smith, personal communication).

Several state agencies are working with species and varieties of mountain-ash from Europe and Asia. The aim is to find good fruit-producing forms suited to particular areas. Few conclusions have been reached, and seed or plant sources are limited; but stock better

suited to local conditions may be found and made available in the future.

Established plants should be stimulated to develop large crowns by killing or cutting back competition. It is not necessary or desirable to entirely open up the area around and over the plants. Natural seeding might be encouraged by exposing mineral soil near seed sources during good seed years. Protection of seedlings and saplings from browsing might also be practical for several years.

If control were ever necessary, girdling or application of an herbicide would be sufficient.

MOUNTAIN-LAUREL

Kalmia latifolia L.

Also called Calico-Bush, Ivy, Ivy Bush, Laurel, and Spoon-wood.

By Sadie L. Robinette

*West Virginia University
Morgantown*

RANGE

Mountain-laurel is native to the Atlantic Coastal Plain and Appalachian Mountains from Maine to Florida and west to Indiana and Mississippi (*Kurmes 1961, U. S. Forest Service 1948*).

HABITAT

Optimum climatic conditions for the growth of mountain-laurel have not been determined, but thickets reach their largest size in the southern Appalachians of West Virginia, Virginia, and Kentucky. Mountain-laurel occurs naturally on acid soils, usually within the pH range of 4.0 to 6.5 (*Kurmes 1961, Spurway 1941*). Where acid conditions exist, it will grow on rocky, gravelly, sandy, or peaty soils in a variety of sites. Soil moisture is an important factor in distribution. Survival in the first year after germination depends on a good moisture supply to the small, shallow root system. Mountain-laurel reaches its greatest size on moist sites, and rarely occurs on boggy saturated soils (*Kurmes 1961*).

From the Catskill region south through the Appalachians, mountain-laurel is a common

understory plant of oak and mixed hardwood forests on acid sites. It is usually associated with other heath shrubs. In the Catskills, mountain-laurel, blueberries, azaleas, and tea-berry are abundant on lower slopes beneath mixed hardwoods. Heath communities occur on all the ridges of the ridge and valley area of Pennsylvania, West Virginia, Virginia, and Maryland. In this region, mountain-laurel, blueberries, and huckleberries appear to have invaded the openings left by dying American chestnut trees (*Braun 1950*).

Approximately 3 million acres of southern Appalachian mountain lands are occupied by stands of mountain-laurel and rhododendrons (*Wahlenberg and Doolittle 1950*). Laurel, rhododendron, and several species of azalea and blueberry are the dominant shrubs of the heath barrens which occur in the mountains of West Virginia (*Core 1966:55*). Scrub oaks, laurel, and other heaths are also some of the most abundant shrubs of the New Jersey Pine Barrens (*Braun 1950:270*).

LIFE HISTORY

Flowering occurs from early May in the southern Appalachians to late June in New

England. Insects pollinate the showy pink to white blooms, which remain for 2 to 3 weeks. Seeds mature in small five-part capsules, which may contain more than 700 seeds, but average 500 to 600. The dustlike seeds are less than 0.04 inch long and 0.02 inch in diameter. Despite their small size, wind scatters them relatively short distances, and seedlings are rarely found more than 50 feet from mature plants. Seedfall begins in November and continues until spring. Seeds remain alive through the winter in the capsules and on the forest floor (Kurmes 1961).

Mountain-laurel regenerates by seeds, layers, sprouts, and suckers. Flowering is much more profuse in open sunlight than in partial shade and rarely occurs in deep shade (Kurmes 1961). Production of new stands by seeding usually occurs after logging, fire, or other disturbance (Chapman 1950). In Connecticut, most natural seedlings were found on beds of dense, low moss. Several species of low moss commonly occurred where the forest floor had been disturbed, and they provided a stable, moist bed for laurel seeds. Germination also occurred on bare mineral soil; survival was rare where thick litter, deep moss, or other plants covered the soil (Kurmes 1961). Increase in stand density and lateral spread appear to be caused by a combination of seeding and natural layering (Kurmes 1961, Little 1944). Laurel sprouts vigorously from dormant buds along the stem or the root burl after injury by fire or cutting (Kurmes 1961).

Growth rate of laurel depends on site conditions. Generally, sprouts grow faster than seedlings, and growth rate declines with age. In the southern Appalachians, stands averaging 8 feet tall were about 20 years old, with a mean annual height growth of 0.4 foot (Wahlenberg and Doolittle 1950). In Connecticut, laurel stands were about 6 feet tall when 30 to 45 years old, but when these stems were cut to the ground the sprouts grew 17 inches tall in 4 years (Chapman 1950). One-year-old seedlings growing beneath a hardwood overstory averaged less than 1 inch tall (Kurmes 1961: 23).

The life span of mountain-laurel thickets and stems is probably as variable as the growth rate. In Connecticut, 35- to 45-year-

old thickets were still growing taller; and in the southern Appalachians 60-year-old stands are common (Chapman 1950). One 110-year-old laurel stem has been reported (Kurmes 1961).

Mountain-laurel is moderately shade-tolerant, but growth is more vigorous in the open. Seed germination apparently is best in partial shade, but under heavy shade laurel plants produce few flowers and eventually die (Eiser 1961).

USE BY WILDLIFE

Mountain-laurel provides valuable winter cover for white-tailed deer, eastern cottontails, snowshoe hares, and ruffed grouse, especially where it is the major evergreen ground cover. Acetylandromedol, a resinous substance in the leaves, twigs, and nectar of mountain-laurel, is poisonous to livestock (Hardin 1966). Sheep, goats, cattle, and possibly horses have died from eating laurel, but wild animals are not poisoned (Hardin 1966, Marsh 1930:19). Sixteen white-tailed deer fed nothing but mountain-laurel and rhododendrons for 45 days became thin and weak, but showed no sign of poisoning (Forbes and Bechdel 1931). One deer died after being force-fed laurel leaves equivalent to 1.75 percent of its live weight; a second deer recovered from a dose equivalent to 1.29 percent of its body weight (Forbes and Bechdel 1931).

White-tailed deer eat small amounts of laurel foliage wherever it is found: but in West Virginia, laurel and rhododendron appear to be preferred foods (Core 1966:22). Mountain-laurel is one of the 25 most important grouse foods in the Northeast. Leaves are eaten during fall, winter, and early spring when green leaves of most other plants are lacking (Edminster 1947:121). Black bears eat small amounts of leaves, buds, and capsules (Martin et al 1951:352-3).

PROPAGATION

Seeding, layering, and cuttings are the major means of propagating mountain-laurel. The vegetative methods are used for preserving genetic traits; seeding is best for quantity production. Mountain-laurel seeds (and

plants) are available from commercial nurseries, or ripe brown capsules may be collected from local plants from September through January. Capsules should be airdried, crushed, and shaken through a 0.0197-inch (0.5-mm) mesh screen to separate the seeds from the chaff (*Kurmes 1961*).

Seed storage conditions do not appear to be critical. One study found no difference in germination between seeds stored for 10 weeks at sub-freezing temperatures and those kept under warm dry conditions (*Kurmes 1961*). Others recommend exposing laurel seeds to outdoor winter temperatures for 2 or 3 months before sowing (*Wells 1955, U. S. Forest Service 1948*).

Seeds are normally sown in the greenhouse in late March or early April. An equal mixture of sand and peat, sifted sphagnum or peat, and living low mosses, all make good seedbeds (*Kurmes 1961*). Sandy soil can also be used, but hardwood leaf litter is not suitable (*U. S. Forest Service 1948, Kurmes 1961*). Germination occurs in 2 to 2½ weeks and may be as high as 90 percent (*Kurmes 1961*). Seedlings should be removed from the seedbed when 3 months old, or after the first true leaves appear. It is best to move plants directly outside to a shade-house or frame, but they can be kept in the greenhouse until the following year.

Seedlings kept in the greenhouse should be planted at least 1½ inches apart in flats containing an equal mixture of sand and peat moss. They should be shaded during the summer, and the temperature should be kept near 60° F. Keeping plants in the greenhouse until they are a year old often requires additional transplantings (*Laurie and Chadwick 1931:142*). Direct transplanting from seedbed to shade house can be done in late June or early July. Seedlings should be planted at 3 to 4-inch intervals in rows 6 inches apart, and the soil should contain a large amount of peat moss to insure the necessary acidity. Watering and weeding should be done as needed, but cultivation should be stopped at least a month before the first frost to allow the plants to mature. Seedlings should be protected during the winter by heavy mulching or sash if they are in suitable frames. Two- and three-year-old

stock should be used for field plantings (*Laurie and Chadwick 1931:142*).

From late spring to midsummer, mountain-laurel may be propagated by layering. Lateral branches of established plants are bent to the ground, pegged in place, and covered with soil. Roots develop where the branch is in the soil. Layered stems should be watered in dry seasons and occasionally checked for roots. Most layered branches form good roots in 1½ years. When firmly rooted, the layered stem should be severed from the parent plant, but left in place for another year before transplanting (*Laurie and Chadwick 1931*).

No reference was found to direct-seeding in the field, but the method should work where the seedbed and soil are suitable. Layering could be used to increase the size or density of existing laurel stands.

MANAGEMENT

Because of its esthetic appeal, mountain-laurel is often encouraged along roadways, and in parks or other areas where scenery is important. It can be used as an ornamental on most acid sites and makes an excellent natural screen. Many kinds of wildlife find cover in laurel thickets, and where other low evergreen cover is lacking, some laurel should be preserved. Stands can be rejuvenated by removing overtopping trees and cutting laurel stems to cause sprouting. Laurel thickets are often so dense and large that they interfere with timber regeneration and other forest uses (*Wahlenberg and Doolittle 1950, Chapman 1950*).

Planting with white pine has been recommended for converting Southern Appalachian laurel thickets to timber production (*Minkler 1941, Wahlenberg and Doolittle 1950*). Planting can be done most economically in the numerous openings left by tractor logging. Timber should be harvested in winter, and seedlings planted in early spring of the same year. Where trees are absent, site conversion requires hand clearing or bulldozing before planting.

Spraying with 2,4,5-T has been effective for eliminating small clumps of laurel, but costs too much for extensive treatment. A basal spray of 2,4,5-T in oil (20 pounds acid equiva-

lent per 100 gallons) gave 89 percent crown kill and excellent sprout control. Sprouting was also controlled on laurel stumps sprayed with 2,4,5-T (*Studer 1958*).



RED MULBERRY

Morus rubra L.

By Earl L. Core

West Virginia University
Morgantown

RANGE

Red mulberry occurs from Vermont and Massachusetts to New York, extreme southern Ontario, southern Michigan and Wisconsin, southeastern Minnesota and southeastern Nebraska, south to central Kansas, western Oklahoma, and central Texas, and east to southern Florida.

There is evidence that red mulberry, once common, is vanishing from at least a portion of this range, possibly because of a bacterial disease. Mature fruiting trees are now scarce in many areas (*Affeltranger 1965, Core 1966: 75*). Its place is often being taken by the introduced and escaped white mulberry (*M. alba*), which may be confused with red mulberry because its fruits, typically white at maturity, may be pink or pale purple to nearly black (*Strausbaugh and Core 1952-64*).

HABITAT

Red mulberry grows under a wide variety of climatic conditions, from the northern forests of New England to the warm regions of the Gulf Coast and the subtropical forests of Florida. Rich soil of flood-plain forests seems best for the growth of red mulberry. A pH range of 6.0 to 7.5 has been reported as optimum (*Spurway 1941*).

Towards the south, common species associated with red mulberry include sycamore, American elm, silver maple, and sweetgum.

Northwards it is associated with American elm, red maple, boxelder, and white ash.

LIFE HISTORY

Male and female flowers are usually borne on separate trees, but sometimes they may occur on the same tree. Pollen is carried by the wind in April and May. The fruit, somewhat resembling an elongate blackberry, is composed of numerous juicy drupelets formed from separate female flowers ripening together in July. The entire fruit is 0.5 to 1.5 inches long, dark red in color, and quite sweet.

The minimum commercial seed-bearing age is reported as 10 years, the optimum 30 to 85, and the maximum 125 years. The seeds are minute, with thin membranous coats. A variety of song birds and mammals disperse the seeds, and seed has apparently been the primary source of new stands of red mulberry (*Fordham 1967*). There is little evidence of reproduction by sprouting or other vegetative means. In original forest conditions, red mulberry apparently made good growth in shade, but in many areas where the trees were once common, seedlings are no longer found.

USE BY WILDLIFE

At the season of ripening, red mulberry fruits are among the most popular foods of songbirds. The trees attract large numbers of birds, which do not even wait until the fruits are ripe before they start eating them.

Birds listed as important feeders are cardinal, catbird, crow, Baltimore oriole, starling, brown thrasher, wood thrush, cedar waxwing, and red-headed woodpecker. Birds having mulberry fruits as a somewhat lesser proportion of their diet are crested flycatcher, purple grackle, rose-breasted grosbeak, northern blue jay, kingbird, robin, English sparrow, scarlet tanager, and tufted titmouse. Opossums, raccoons, fox squirrels, and eastern gray squirrels also eat mulberries in appreciable amounts; and cottontail rabbits feed on the bark in winter (Martin et al 1951, Trippensee 1938). Red mulberry has little or no value as cover for wildlife.

PROPAGATION

Ripe mulberry fruits may be collected by shaking them from the trees onto a tarpaulin. The berries are mashed and soaked in water for 24 hours, then run through a macerator, floating off the pulp. About 2 to 3 pounds of seed are yielded by 100 pounds of fruit. Number of cleaned seeds per pound range from a low of 200,000 to a high of 500,000, with an average count of 360,000 (U. S. Forest Service 1948). It is recommended that the seed be stored dry in sealed containers at 41 F (U.S. Forest Service 1948).

The best natural seedbed is a moist, rich, loamy soil, at least partially protected by litter or vegetation. Germination begins in the spring. Laboratory tests show that the germination rate is poor. Stratification in moist sand for 90 to 120 days at 41°F helps to overcome the dormancy. Mulberry seed mixed with sand or sawdust may be sown in drills in October or November, or seed that has been stratified may be sown in the spring and covered with one-fourth inch of soil. Good results are secured from drills 8 to 12 inches apart, using about 50 seeds to the linear foot of row.

Fall-sown beds should be mulched with straw or leaves and protected by shade screens until germination begins in spring. Spring-sown beds should be mulched with burlap and kept moist until germination begins. Seedbeds should be given partial shade for a few weeks after germination begins. Germination usually takes place 1 to 2 weeks after spring sowing (U. S. Forest Service 1948). Seedlings should

be hardened off to prevent frost injury (Munns 1938). Seeds are reported as germinating rapidly at alternating temperatures of 68 to 86°F in light without any pre-chill treatment (Heit 1968). One-year-old seedling stock is used for field planting.

Red mulberry can be propagated from stem cuttings or by budding, but both methods are complex and require a greenhouse (Halls and Alcaniz 1965a, Munns 1938). Stem cuttings taken in May, September, and January and treated with indole-butyric acid had an average of 7 percent developing roots regardless of time of year (Halls and Alcaniz 1965a).

MANAGEMENT

Some birdwatchers say that if they could choose only one fruiting tree to attract birds, they would select the mulberry. Although it is a desirable plant in bird sanctuaries, parks, and campgrounds, red mulberry is not recommended for general wildlife plantings. It has relatively little value as wildlife cover or for soil conservation.

In planting trials, survival has been consistently very poor. Of seven plantings made from New York to West Virginia, none had more than a few scattered plants remaining after 5 to 8 years. The few plants that lived made fair to good growth, ranging from 5 to 18 feet; but none fruited (Edminster and May 1951).

Red mulberry stands of any size are not mentioned in the literature, and the species is becoming scarce in many areas, perhaps because of disease. *Pseudomonas mori* is reported as causing a moderately severe disease, manifested chiefly as a leaf spot and blight (Pearce and Spaulding 1942). *Mycosphaerella mori*, the cause of leaf spot in red mulberry, is widespread and abundant. Mulberry is also attacked by the Texas root rot caused by *Phymatotrichum omnivorum* (Van Dersal 1938). The cerambycid borer *Dorcaschema wildii* is a destructive insect pest southwards (Solomon 1968).

Fenuron has been used as a herbicide to control weeds in mulberry seedbeds.

Mature mulberry trees have been used for lumber, and the timber is especially good for lathe work.

BEAR OAK

Quercus ilicifolia Wangenh.

Also called Bitter-Bush, Bitter Oak, Black Scrub-Oak, Dwarf, Black Oak, Holly Oak, Jack Oak, Red Brush, Scrub Oak, Turkey Oak.

By Leonard J. Wolgast
Rutgers University
The State University of New Jersey
New Brunswick

RANGE

This species occurs from southern Maine to New York and Pennsylvania, south to West Virginia, western North Carolina, and Virginia (*Little 1953*).

HABITAT

Bear oak occurs on acid, rocky or sandy, sterile soils, especially on dry sandy barrens and rocky hillsides. It is found at elevations ranging from sea level to about 3,000 feet (*Society of American Foresters 1967*). A soil pH of 4.5 to 6.0 is optimum for the growth of bear oak, and a pH of 7.5 is the maximum it will tolerate (*Spurway 1941*). Bear oak has been observed to remain healthy and produce acorns on soils having a pH as low as 3.8, and acorn production was not related to soil acidities between pH 3.8 and 4.6 on New Jersey's outer Coastal Plain (*Wolgast 1972*).

The conifers associated with bear oak include these pines: Virginia, pitch, white, table-mountain, and shortleaf. Hardwood associates include chinkapin, scarlet oak, black oak, northern red oak, chestnut oak, dwarf

chinkapin oak, black locust, red maple, sassafras, and blackgum (*Society of American Foresters 1967*). The chief upland shrubs associated with bear oak in the pine region of New Jersey are huckleberries and lowbush blueberries; sweetfern and hawthorn are less common associates (*Little et al 1958*). Mountain-laurel is usually the most common shrub associate at higher elevations.

LIFE HISTORY

The male flowers are borne in thin drooping aments, 1½ to 3 inches long. These occur on the growth of the preceding season or from the axils of the scales of the terminal buds. The female flowers, which occur on the same tree, are borne in the leaf axils of the current season. Flowering occurs in April, May, and June, when the leaves are approximately one-fourth to one-half grown. Wind spreads the pollen; and the fruit, an acorn, ripens during September and October of the following year (*Brown 1938*).

Some specimens planted for wildlife in New York and Pennsylvania produced acorns by the eighth year (*Edminster and May 1951*).

Three-year-old sprouts have been observed bearing acorns in New Jersey, and 24-year-old trees have also continued producing acorns. Acorn production is highest in stands of even-aged sprouts ranging in age from 5 to 8 years. Beyond 8 years of age, acorn yields begin to decline (*Wolgast 1972*).

Although this species is considered to be a prolific bearer (*Brown 1938*), acorn crops are highly variable. Two climatic factors that contribute significantly to this variability are high relative humidity at the time of flowering, and late-spring frosts. Some trees are inherently good producers of acorns while others are inherently poor producers (*Wolgast 1972*).

Seed is spread by birds, mammals, and gravity; but the distance of spreading is not definitely known.

Bear oaks reproduce from seeds or by sprouting from the root collar. After a rapid initial period of growth to a height of 4 to 5 feet, height growth occurs at the approximate rate of 1 foot every 4 years on New Jersey's outer Coastal Plain. This growth rate may vary considerably from site to site and has not been studied beyond the age of 24 years (*Wolgast 1972*).

Bear oak grows best in full sunlight. It readily invades openings created by clearcutting or fire. It will persist in the understory of a pine stand, but studies on New Jersey's outer Coastal Plain indicate that acorn production is lower on trees growing in shade (*Little et al 1958*).

USE BY WILDLIFE

Turkeys, grouse, quail, squirrels, deer, and bear feed extensively on bear oak acorns. Deer also browse on the foliage and twigs. The acorns are also utilized by many smaller birds, particularly jays and woodpeckers. The small size of the acorns makes them readily swallowed (*Edminster 1947; Martin et al 1951; Van Dersal 1938*).

Bear oak often grows in thickets, which provide excellent cover for many wildlife species during all seasons.

The ability of bear oak to grow on exposed sites makes it valuable as a cover tree, protecting the site until other species can get started (*Brown 1938*).

PROPAGATION

Seed or stock is not available commercially. However, seed can be harvested in September and October from existing stands. The seed may be removed from the cup, or the entire acorn may be planted. One hundred pounds of acorns may be expected to yield approximately 75 pounds of clean seeds, and 1 pound of clean seed contains 500 to 700 seeds (*Edminster 1947*). The Eastern Tree Seed Laboratory reported in 1970 (*Darrell Benson, personal communication*) that maximum germination response (95 percent) and good germination speed was obtained after 90 days of stratification at 38°F. This confirmed an earlier report that up to 95 percent germination may be expected in bear oak (*Edminster 1947*).

Optimum seed storage conditions for bear oak are unknown, but dry storage in sealed containers at temperatures of 32 to 36°F is successful for other oaks. Over-winter storage may also be accomplished in well-drained outdoor pits below the frost line.

Stratified seeds may be sown in the spring, or fresh seeds may be sown directly in the fall at the rate of 10 acorns per square foot or 2 pounds per 100 square feet. The beds should be covered with 1 inch of firmly packed soil and a mulch of straw or leaves. Covering the beds with hardware cloth holds the mulch in place and protects against rodents. The mulch should be removed when danger of frost is over in the spring, and the soil should be kept moist until germination is complete (*U. S. Forest Service 1948*).

Direct fall seeding in the field may be more desirable than the planting of nursery stock except where risk of acorn loss to rodents is high. In areas where it is desirable to use nursery stock, 1-0 seedlings are satisfactory (*U. S. Forest Service 1948*).

MANAGEMENT

Burning, cutting, and routing increased sprouting by bear oak. Single-stem plants so treated may produce up to 40 or more new stems (*Worley et al 1957*).

Since bear oak grows on infertile areas

Food is often the factor limiting wildlife, and management should include treatments to increase acorn production. In New Jersey the basal application of 800 pounds per acre of 2,4,5-T fertilizer resulted in a significant increase in the acorn crop; sprouts that were 8 years old exhibited a significantly greater response to fertilizer than younger ones. Bear oaks fertilized at this same rate produced significantly greater quantities of acorns at all ages (*Wolgast 1972*).

Bear oak is difficult to control because of its sprouting habit, but some success has been attained by using 2,4,5-T esters in oil as a basal spray. Optimum top-kill was obtained by carefully and completely encircling the basal portion of the stems with 2,4,5-T esters in oil at a minimum concentration of 2 percent by volume. To avoid resprouting, the treating solution must cover the root collar of the plant. Early winter treatments were most successful (*Worley et al 1957*).

PARTRIDGEBERRY

Mitchella repens L.

Also called Checkerberry, Creeping Chequer Berry, Deer Berry, Hive Vine, One Berry, Pain de Perdrix, Running Box, Squawberry, Squaw Vine, Twinberry, Two-Eyed Berry, Two-Eyed Chequer Berry, and Winter Clover.

By Charles M. Nixon
*Ohio Department of Natural
Resources
New Marshfield*

and

D. Michael Worley
*Ohio University
Athens*

RANGE

Partridgeberry occurs from southwestern Newfoundland, southern Quebec, Ontario and Minnesota south to Florida and Texas (*Fernald 1950*).

HABITAT

Partridgeberry is acclimated to nearly all the extremes of climate in the Northeast, but is generally confined to mildly acid soils (pH 4.5 to 6.0) with a high organic content (*Laurie and Chadwick 1931*). The optimum pH range was reported as 5.0 to 6.0 (*Spurway 1941*). If moisture is present, partridgeberry even grows in shallow leaf mulches on rock substrates. It is found in both moist and dry situations; but in the southern portions of the region, at lower elevations, it is usually found in coves or lower north and east-facing slopes (*Braun 1950*).

In the hemlock-white pine-northern hardwood community, partridgeberry is closely associated with hemlock. Understory associates include bunchberry, hard and soft maples, beech, birches, hobblebush, and beaked hazel.

In the hemlock-mixed mesophytic forest, partridgeberry is often dependent on hemlock leaf mold, but is also found in the beech-maple and mixed hardwood communities transitional to oak chestnut. In the oak-chestnut forest featuring mixed oak and hemlock, partridgeberry is usually found beneath hemlock or rhododendron understories (*Braun 1950*).

LIFE HISTORY

To insure cross-pollination, flowers of partridgeberry are of two kinds (styles and stamens differ) and are joined in pairs, either terminal or axillary. Flowering occurs from May to July, and the blossoms are white, often fringed with purple. Fruits turn scarlet as they ripen in August and September, and often persist throughout winter (*Braun 1961*). The fruit is a twin drupe with eight nutlets, formed by fusion of the paired flowers. Seeds are usually spread through ingestion by birds and mammals.

Partridgeberry is not a prolific seeder. In southeastern Ohio, we examined mats of partridgeberry for mature fruit in early October. Ten mats totaling 369 square feet averaged

only 0.51 fruits per square foot (range 0.12 to 0.75).

Twelve pounds of clean seed was obtained from 100 pounds of fruit, and there were 198,400 seeds per pound of seed (*Swingle 1939*).

Partridgeberry reproduces by seed and by stem-rooting at the leaf nodes. Stems grow along the ground, forming dense mats with individual stems 4 to 12 inches long (*Gleason 1963c*). The growth rate per stem has not been reported.

Partridgeberry is very shade-tolerant. The mat-type growth and the heavily shaded habitat favored by partridgeberry tend to discourage competition by herbaceous plants (*Braun 1950*).

USE BY WILDLIFE

The fruits are eaten by ruffed grouse, bobwhite quail, wild turkey, spruce grouse, red fox, skunks, white-footed mice, raccoons, opossums, and squirrels in fall and winter (*Goodrum 1940, Korschgen 1967, Martin et al 1951, Van Dersal 1938*). Partridgeberry was reported as one of the 25 most important foods of the ruffed grouse in the Northeast by Edminster (*1947*). The fruits were eaten by grouse during the fall and winter while the leaves were eaten rather consistently year-round. Partridgeberry stems and leaves made up a small portion of the winter diet of deer in Massachusetts (*Hosley and Ziebarth 1935*) and were eaten in small quantity during spring, fall, and winter by deer in Ohio (*Nixon et al 1970*). Partridgeberry has little or no cover value.

PROPAGATION

Seed is not usually available commercially, but rooted cuttings can be obtained from wild-plant nurseries. Seeds should be collected

in the fall and sown either in late winter or spring. Stem cuttings may be taken in spring or fall. Root divisions should be made in the spring (*Laurie and Chadwick 1931*).

In the nursery, seeds may be sown during January or February, in a peat-soil-sand mixture, and lightly covered with peat. Seeds will usually germinate in 2 to 3 weeks if the soil is kept moist and at 60 to 65°F. In about 3 months, plants are large enough for transplanting into flats. Temperatures should remain below 60°F for best growth (*Laurie and Chadwick 1931*).

Under greenhouse conditions, stem cuttings produced roots in 4 to 6 weeks at a temperature of 40 to 45°F (*Laurie and Chadwick 1931*).

No information is available about direct-seeding of partridgeberry. Spring transplanting of either rooted cuttings or root divisions would seem to provide the most rapid method of establishment. Transplants should be made on mildly acid soils in shaded sites, preferably under hemlock. Either moist or dry situations are acceptable, but soils should be high in organic matter.

MANAGEMENT

Once established, partridgeberry grows best in shade. Ordinarily the overstory trees, particularly hemlock, should not be removed because competition in cut-over stands may reduce or eliminate partridgeberry, at least until shade is reestablished. Light commercial thinning or weeding, using single tree selection, seem best for maintaining mats of partridgeberry (*Edminster 1947*). In certain communities, hemlock is necessary for maintenance.

Although specific control recommendations were not found, herbicide treatment such as 2,4-D or 2,4,5-T applied as a foliage spray in midseason should control partridgeberry. Such control is seldom necessary.

RHODODENDRON

Rhododendron maximum L.

Also called Great Laurel, Rosebay, Rosebay Rhododendron, and White Laurel.

By Sadie L. Robinette

West Virginia University
Morgantown

RANGE

Rhododendron grows from southwestern Maine to Vermont, New York, and extreme southern Ontario to Ohio and Pennsylvania, south in mountains to eastern Tennessee, northern Alabama, northern Georgia, western South Carolina, and western North Carolina (*Little 1953*).

HABITAT

Rhododendron grows on acid soils, usually within the pH range of 4.5 to 5.5 (*Kellogg 1952, Leach 1961*). In the northern part of its range, rhododendron occurs in isolated colonies in deep, cold swamps. It is abundant along the mountain streams in western Pennsylvania, and becomes common farther south, occupying steep stream banks up to altitudes of 4,500 feet (*Cox and Cox 1956*). It reaches its largest size and grows most profusely in the southern Appalachians, where it often forms thickets many acres in size (*Sargent 1922*).

Rhododendron and eastern hemlock (*Tsuga canadensis*) have similar ranges and site preferences (*Hodgdon and Pike 1961*), and in most areas they are closely associated (*Braun 1950*). In New England and southeastern

Canada, rhododendron occurs locally in bogs and in bog borders beneath hemlock-white pine or hemlock-beech stands. In the Catskill and Allegheny mountains it is frequently the only understory beneath hemlock stands along streams, and it is also a dominant shrub in shady, moist ravines in the ridge and valley area of Pennsylvania, West Virginia, and Maryland.

LIFE HISTORY

The large pink or white flowers bloom from June in the south to August in the northern part of our region. Insects pollinate the flowers. The fruit is an oblong capsule, which turns greenish brown when ripe. Seeds are less than 1/32 inch long, brown, and tufted at each end. Each capsule contains 300 to 400 seeds (*Romancier 1969*), and there are 5,000,000 to 5,700,000 seeds per pound (*U. S. Forest Service 1948*). Ripe capsules split along five lines to release the seeds, and wind disperses them for short distances (*Bailey 1916*).

Rhododendron reproduces from seeds, sprouts, layers, and suckers; but seeding and layering are the principal means of regeneration for natural stands. Disturbances such as

cutting or burning usually result in vigorous regeneration from stump sprouts, root suckers, and sprouts from layered stems (Yawney 1962).

Rhododendron is moderately shade-tolerant; seed germination is best under partial shade (U. S. Forest Service 1948). Sprouting perpetuates rhododendron thickets, but its own seedlings are seldom found within the perimeter of a given thicket (Robert Romancier, personal communication). Rate of growth depends on the nature of the site. In Georgia and North Carolina, rhododendron thickets were 8 feet tall when 15 years old, and 11 feet tall when 26 years old. Sprouts that developed after cutting these stems to the ground grew 4 feet tall in 6 years (Wahlenberg and Doolittle 1950). The range in average age for eight rhododendron stands in North Carolina was 48.6 to 61.4 years (Smith 1963). Individual stems commonly reach 70 years of age, but none over 85 years old was found (Romancier, personal communication).

USE BY WILDLIFE

Rhododendron is valuable as winter and escape cover for white-tailed deer, eastern cottontail, black bear, snowshoe hare, ruffed grouse, wild turkey, and many songbirds. Rhododendron is heavily browsed by deer during the winter in Pennsylvania and West Virginia (DeGarmo and Gill 1958, Latham 1950). Ruffed grouse take leaves, buds, twigs, and seeds (Edminster 1947). Leaves are eaten by several small mammals, including the white-footed mouse and Allegheny wood rat (Martin et al 1951).

PROPAGATION

Rhododendron seed is available from Forestry Associates, PO Box 1969, Allentown, Pennsylvania; or capsules may be collected from wild plants from October through January. After air-drying, capsules can be rubbed or beaten if they have not already split open, and the seeds can be shaken out.

Seeding, layering and cutting are the major means of propagating rhododendron. The method used depends on the objective; vegetative means are needed to preserve genetic

traits. Attempts to establish rhododendron should be limited to acid soils with a high content of organic matter and ample soil moisture at all times (Hottes 1931, U. S. Forest Service 1948).

Following standard nursery and greenhouse propagation techniques (Bowers 1960, Laurie and Chadwick 1931), seed should be air-dried and stored in sealed containers after removal from the capsule. Seed may be kept at room temperature if it will be used in a month or two; but for longer storage, seed should be refrigerated at 40 to 50°F.

The seed should be planted in the greenhouse in January or February. Wooden flats or any small container that allows good drainage can be used for planting. The soil mixture should be acid in reaction and porous. A good planting mixture can be made from decayed oak litter, sand (about 25 percent by volume), and a small amount of peat moss. The soil should be firmed in the flats and covered approximately $\frac{1}{4}$ inch deep with ground sphagnum. The seeds should be broadcast directly on top of the sphagnum, and partially covered with a very light additional coating of ground sphagnum.

The soil should be thoroughly watered at planting time. The temperature should be kept at 60°F at night and from 65 to 70°F during the day; lower temperatures delay germination. At these temperatures the seeds require 16 to 20 days for germination, and an average germination of 85 percent can be expected (Romancier, personal communication). Seedbeds should be kept well watered after germination. At age 3 months, or as soon as the first true leaves appear, the seedlings should be separated carefully and planted at least $1\frac{1}{2}$ inches apart in flats containing the soil mixture used for planting. Partial shade is necessary, and temperatures should be kept near 60°F, which is relatively cooler than optimum temperature for germination.

Seedlings may be carried through the first summer outdoors or in the greenhouse. Keeping plants in the greenhouse often requires two or three additional transplantings, plus careful attention to shading and watering. It is best to place plants outside in a shaded frame or shade house. Seedlings should be

moved outside during late June or early July, and transplanted into rows 6 inches apart with a 3 to 4-inch spacing in the row. The soil should contain a large amount of organic matter such as peat moss to insure the necessary acidity. Seedlings should be watered and weeded regularly; but to allow the plants to mature before winter, watering and cultivation should stop by mid-August.

Rhododendron seedlings left outside during the winter should be protected by heavy mulching or sash if they are in suitable frames. Sash may be covered with straw mats or loose hay if further protection is necessary. Mulching and pest control should be done carefully in the winter. Transplanting to the open field should take place during the third or fourth spring.

Nurserymen commonly use leaf and stem cuttings to propagate rhododendron. A greenhouse is a necessity; and the process is difficult, so it will not be covered.

From late spring to midsummer, rhododendron may be propagated by simple layering, a process in which branches from well-established plants are bent until they touch the ground. The part touching the ground is covered with soil, but the leaves at the tip of the branch are left exposed. Roots will develop along the underside of the branch. In the nursery, layered branches should be watered during dry seasons and checked for roots occasionally. Most branches will form good roots in 1-1/2 years. When adequate roots develop, sever the new plants from the parent, but leave them in place for a year. After this time, plants may be transplanted to new sites.

Layering is generally a nursery practice, but it appears to be a good field technique for increasing the number of plants where some already exist. No reference to direct-seeding in the field was found, but in nurseries, sowing seeds outside during April has been successful. Seedbeds were prepared the same way as in the greenhouse.

MANAGEMENT

Rhododendron is an excellent ornamental; and once established, it requires little maintenance. Rhododendron's dense growth form and evergreen leaves make it well suited for use as a natural screen. The variety of landscaping uses for the plant is limited only by its soil requirements and the manager's imagination. Natural stands provide protection for watersheds and cover for wildlife. In areas where rhododendron is the principal evergreen cover, some consideration for its preservation should be included in management plans. Rhododendron sprouts rapidly after injury, and cutting is an excellent method for rejuvenating stands.

Extensive stands of rhododendron, common in the southern Appalachians, may present control problems (*Wahlenberg 1950*). Thickets reach their best development on better sites, where they often prevent natural regeneration of timber trees and may interfere with other forest uses. Planting with white pine has been recommended for converting southern Appalachian rhododendron thickets to timber production (*Minckler 1941, Wahlenberg and Doolittle 1950*). Planting can be done most economically in openings left by tractor logging. Timber should be harvested in winter, and seedlings planted in early spring of the same year. Where timber trees are absent, site conversion requires hand-clearing or bulldozing before planting.

The following rhododendron control treatment was used at the Fernow Experimental Forest in northern West Virginia. A 20-pound acid equivalent per 100 gallons mixture of 2,4,5-T in diesel oil was applied by a hand sprayer to stem cuttings or stumps, and as a basal spray. Rhododendrons were killed by both treatments, but high cost made these methods suitable only for eliminating scattered clumps (*Yawney 1962*).

In a study conducted on the Bent Creek Forest near Asheville, North Carolina, treating stumps with 2,4,5-T gave good sprout control (*Sluder 1958*). Good top kill was obtained with sodium arsenite, but sprouting was heavy; and the chemical is highly toxic to man and other animals (*Sluder 1961*).

ROSES

CAROLINA ROSE, *Rosa carolina* L. Also called Low, Pasture, or Wild Rose.

JAPANESE ROSE, *Rosa multiflora* Thunb. Also called Bramble, Multiflora Rose, or Rambler.

SWAMP ROSE, *Rosa palustris* Marsh.

PRAIRIE ROSE, *Rosa setigera* Michx. Also called Climbing or Michigan Rose.

VIRGINIA ROSE, *Rosa virginiana* Mill. Also called St. Mark's Rose.

By Margaret Smithberg

*University of Minnesota
St. Paul*

and

John D. Gill

*Northeastern Forest
Experiment Station
Morgantown*

RANGE

All five species occur throughout the Northeast south of a line from southern New England to Michigan. Three species also range northward into Canada:

Carolina rose—Nova Scotia, southwestern Maine to southern Ontario, Minnesota.

Swamp rose—Nova Scotia, southern Quebec to Minnesota.

Virginia rose—Newfoundland, Nova Scotia to southern Ontario.

Roses hybridize freely and it is often difficult to distinguish them, especially where their ranges coincide (*Grimm 1952*). Carolina rose is the most widely distributed rose in eastern North America, and is quite variable. Virginia rose is the most common rose in New England, but in the southern limits of its range it may be confused with Carolina rose.

Swamp rose is found in practically all states east of the Mississippi River, but is often confused with Carolina rose; however, swamp rose is more common in moist situations. Prairie rose is most common in Ohio and the central Mississippi Valley, and is sparse elsewhere. It has escaped from cultivation in the eastern part of its range.

Although Japanese rose is not a native, having been imported from Japan and Korea in 1875 (*Shepherd 1954*), it has escaped from cultivation and is commonly found growing in the wild. It is included in this report because it has been used more in conservation work than any other rose species.

HABITAT

In cultivation, clay-loam soils are most commonly preferred for roses; but in the wild, roses occupy many different kinds of soils

(*Shepherd 1954*). Most species thrive on moderately fertile, well-drained, clay-loam, sandy loam, or sandy soils (*Hosely 1938*). And most are relatively insensitive to soil reactions, at least within the circumneutral pH range (*Wherry 1957*).

Carolina rose is often found on dry, sandy, or rocky soils (*Grimm 1952*) and may prefer moderately acid conditions. Swamp rose, of course, grows well on wet soils, and they usually are at least moderately acid. However, the optimum soil reaction was reported as pH 6.0 to 8.0 (*Spurway 1941*). Prairie rose grows best on the better loam soils (*Hosely 1938*). Virginia rose tolerates a wide range of soil and moisture conditions. It thrives in sandy soils (*Zucker 1966*), and is common in dry uplands in Ohio (*Chapman 1947c*). But it has also been recommended for planting in heavy clay soil (*Hottes 1937*). Optimum pH was reported as 6.0 to 8.0 (*Spurway 1941*).

Japanese rose probably requires higher soil fertility than any of the native species. It has been recommended for practically all soils except those that are poorly drained (*Edminster 1947*), but grew poorly on infertile acid soils in New York (*Smith 1964*) and was recommended primarily for "good" loams and loamy sands in Michigan (*Zorb 1966*). Japanese rose was not adapted to the poorer sites on strip-mined land in Ohio and did not compete successfully in established meadows (*Riley 1957*), but has been recommended for some mine spoils with soil reactions of pH 5.0 or higher (*Joseph Ruffner, unpublished report*). In the Southeast, Japanese rose is often found on moderately fertile clay soils (*Rosene 1950*).

Although the roses occupy many kinds of soils, they are restricted mainly to open sites because they are intolerant of shading. Carolina rose has been given a qualified endorsement for landscape use in shaded locations (*Kammerer 1934*), but full sunlight exposure is best for all species. In the open, most species spread easily and often dominate the plant community.

Carolina rose is common on roadsides, in fence rows, woods borders, and thickets (*Grimm 1952*), and is often dominant on dunes and prairies (*Gleason 1963b*). Japanese

rose escapes readily from gardens and fence rows and becomes common in fields, woods borders, hardwood stands, and thickets—wherever birds deposit the seed. In the Southeast it is common in loblolly pine woodlands, but in mixed stands is often spindly (*Rosene 1950*). Swamp rose is commonly found with willows, red-osier dogwood, and other wetland species. Prairie rose grows in open situations such as thickets, fence rows, roadsides, and woods clearings. It often climbs into trees or reclines on shrubs or fences (*Hottes 1937*). In the Midwest, it is common in fields, pastures, and roadsides.

LIFE HISTORY

The roses generally are capable of flowering and fruiting at 2 years of age (*Spinner and Ostrom 1945*) but fruiting may not occur until the third or fourth year. The flower is pollinated by insects and develops into a red, fleshy, berry-like hip. Typically, the hip encloses several small, bony seeds (achenes), ripens in late summer and early fall, and persists on the plant until winter or later—for about 200 days in the Japanese rose (*Gysel and Lemmien 1955*).

Natural establishment of new plants is largely from seeds spread by birds or mammals. Digestion of rose fruits by pheasants and sharp-tailed grouse reduced total germinability but increased germination of those achenes which passed through the birds without harm (*Krefting and Roe 1949*).

Once established, most roses spread by suckering from roots and undergrown stems or by layering. Japanese rose spreads very aggressively on good sites, and may become a serious pest. Growth forms of the roses discussed here are:

Carolina—low, upright shrub.

Japanese—tall; upright to reclining, occasionally climbing; forms dense spiny thickets.

Swamp—medium height, upright, thicket-forming shrub with slender stems.

Prairie—low sprawling or climbing viny shrub with long weak canes.

Virginia—medium height, upright shrub.

Table 1—Roses: growth, flowering, and vegetative reproduction.

Species	Height, feet	Cane length, feet	Flowering dates	Flower color	Spreads by—
Carolina	3-4	—	June-July	Pink	Stolons
Japanese	6-10*	6+	June-July	White	Layers
Swamp	6	to 16	June-Aug.	Pink	Rhizomes
Prairie	1+*	6-18	June-Aug.	Rose to white	—
Virginia	6	—	June-July	White	Stolons, few

*Height varies because Japanese rose occasionally climbs, and prairie rose often does.

Other details of growth, flowering, and vegetative reproduction are in table 1.

All roses grow more vigorously and produce more fruit when growing in full sunlight than when in shade, but Carolina rose may be slightly more shade-tolerant than any of the other four species. Japanese rose plants attain their full height growth in about 5 years (*Edminster and May 1951*). Growth rates for the other species are unknown.

In the wild, roses are relatively free from insect and disease attacks. Japanese rose may be damaged by Japanese beetles, other insects, leaf spot, and crown gall; but no serious injury was noted by Edminster and May (1951). Prairie rose plants growing near the northern limits of the species range may be winter-killed to ground level (*Zucker 1966*).

USES

According to Van Dersal (1938), some reports of the species of roses used by wildlife may be misleading. Accordingly, most of the discussion presented here is for the genus rather than for individual species.

The fruit and other parts of rose plants are eaten by many mammals, especially hoofed browsers. Some roses can withstand browsing that removes nearly two-thirds of the annual growth in spring and summer (*Young and Payne 1948*). Mountain sheep, chipmunks, deer, opossum, and coyote browse on the leaves and fruit (*Van Dersal 1938*), as do bear, beaver, rabbit, snowshoe hare, skunk, mice, antelope, deer, and elk (*Martin et al 1951*). Rose is a preferred food of deer in Kentucky (*Barber 1962*) and Idaho (*Thilenius*

1960). Five years after soil in an area in Western Alberta was scarified, roses provided abundant browse for deer and elk (*Stelfox 1962*).

Japanese rose has been in use in the United States for over 25 years, and its chief value has been for wildlife cover and food (*Dugan 1960*). Its value for wildlife has been shown repeatedly as, for example, in an 8-year study of food-producing plants in Michigan; Japanese rose received more use by wildlife than any other plant (*Gysel and Lemmlein 1964*). However, use has been curtailed in many states because of serious problems in controlling spread of Japanese rose.

Roses are important to wildlife because the fruits remain on all winter, when most other fruits are gone or covered by snow. Ruffed grouse, bobwhite, sharp-tailed grouse, prairie chicken, and wild turkey feed on the fruits (*Van Dersal 1938*). Ruffed grouse feed on roses mostly from October through March in the Northeast; and rose hips, plus some leaves, are among the 25 most important foods (*Edminster 1947*). The hips are a favorite food of pheasants (*Nelson et al 1966*) and turkeys in Indiana (*Schorger 1966*), and the seeds function as grit for grouse and other species. At least 38 species of birds include rose hips in their diet (*Van Dersal 1938*).

Japanese rose provides both food and cover for prairie chickens. The hips were a winter staple for bobwhites but ranked low in nutritional quality as an emergency food (*Newlon et al 1964*). As ruffed grouse food in Missouri, Japanese rose ranked sixth by volume but was heavily used where present (*Korschgen 1966*). Robins and cedar waxwings feed heavily on Japanese rose, which accounts in part for its

rapid spread (Scott 1965). Mockingbirds eat Japanese rose all winter; and it is also taken as winter emergency food by song birds, bobwhites, and pheasants (Davison and Grizzell 1961).

Roses may be as important for wildlife cover as they are for winter food; the thicket-forming species are excellent as nesting and protective cover for game and song birds (Chapman 1947c; Martin et al 1951). For example, in a study in Maryland, the most effective habitat-improvement measure was planting Japanese rose hedges adjoining pastures or with an herbaceous border (Burger and Linduska 1967). Cover formed within 2 or 3 years after planting, and the winter and nesting cover provided by the hedges was considered more important than the food. Elsewhere, Japanese rose provided good winter cover for bobwhite and prairie chickens (Korschgen 1960); and ruffed grouse roost in rose thickets after heavy snowfalls.

The attractive fall foliage and colorful fruit of roses recommend them for landscaping as well as wildlife-habitat uses. Native roses were ranked excellent as roadside plants in Wisconsin (Wisconsin Conservation Department 1967). For general landscaping use, Carolina rose was recommended as a low shrub for dry shady locations (Kammerer 1934). Virginia rose is useful as a large hedge plant, and swamp rose is, of course, suitable for wet areas (Zucker 1966). Japanese rose (Buck 1964), prairie rose, and probably other species, are used as stocks for grafting horticultural varieties of roses. Japanese rose hedges have been recommended as substitutes for fences; after five growing seasons such hedges may confine livestock (Dale 1956).

PROPAGATION

Roses can be grown fairly easily from cuttings or seeds, and Japanese rose seed and planting stock are available commercially. Seeds of the other four species discussed here usually cannot be purchased, but seed of other native species with comparable wildlife values is usually available (Forestry Associates 1970, Northeast Reg. Tech. Serv. Cent. 1971).

For field collection of seed, the hips can be hand-picked soon after the dark green color

fades into red, or anytime thereafter. Seeds collected shortly after fruit ripening may germinate more readily than those allowed to dry out in the hip (Shepherd 1945). Ripening can be speeded up and seed yield increased by wrapping the hips in foil some time before they are to be picked (Lebedeff 1967), and this extra effort may be worthwhile if fruit is scarce.

Seeds can be extracted by macerating the hips in water and floating off the pulp and empty fruit (U. S. Forest Service 1948), or the hips can be crushed and fermented to remove the seed (Laurie 1931). The cleaned seed can be sown immediately, placed in stratification, or airdried for storage. Some seed lots stored dry in sealed containers at 34 to 38° F have shown excellent germination after 4 to 8 years (Heit 1967e).

Data on yield of rose seeds are based on only a few samples. Japanese rose seeds numbered 50,000 to 82,000 per pound of cleaned seed (Swingle 1939). The average for swamp rose was 45,000 seeds per pound, and a bushel of fruit yielded 6 to 8 pounds of cleaned seed (Edminster 1947). Prairie rose yielded 10 pounds of cleaned seed per bushel of fruit and 50,000 seeds per pound of cleaned seed (Hugh Stevenson, unpublished data).

Rose seeds of most species exhibit dormancy, which is due primarily to conditions in the seedcoat rather than in the embryo. Seeds planted without pretreatment may not germinate for 4 months because they contain at least two germination inhibitors (Fletcher 1960). Thus germination is prevented until the seedcoat is either weakened by decay or opened chemically or mechanically.

Jackson and Blundell (1963) found that dormancy could be broken by treating seeds with gibberellic acid or 6-benzylaminopurine. Davis (1943) suggested stratification in damp peat moss in a refrigerator for a few months, then at room temperature until some seeds start to germinate, then at refrigerator temperature again for 6 weeks. Suggested scarification treatments include the rotary file method (Svejda and Voisey 1962), and a sulfuric acid bath for 1 to 2 hours (U. S. Forest Service 1948). However, Heit (1967a) did not recommend sulfuric acid treatment because he

considered the evidence for it to be inconclusive. These special treatments and possibly warm stratification (*Morey 1960*) may be suitable in some circumstances, but ordinary cold stratification will usually be a more practical alternative.

If the seeds are not to be sown immediately, dry storage for as long as needed and stratification at about 40 F for varying numbers of days has been recommended for many rose species. Among the ones discussed here, Japanese rose responded to cold treatment more quickly than Carolina or prairie rose (*Crocker and Barton 1931*), and 28 days at 38 to 41°F may be sufficient for Japanese rose; but a 30- to 60-day period has been recommended (*Heit 1968: pt. 15; Schumacher 1962*). The other species apparently need longer cold treatments: swamp rose 90 to 100 days at 41°F (*Edminster 1947*); and prairie rose 100 days at 32 to 50°F (*Swingle 1939*), or 90 days at 40°F (*Semeniuk et al 1963*). No comparable recommendations for Carolina or Virginia rose were found, but stratification for 90 to 100 days may be adequate; in one study, Carolina rose germinated sooner than prairie rose (*Crocker and Barton 1931*).

The seeds can be stratified in moist peat or vermiculite—the latter gave better results than use of polyethylene bags (*Kozlowski 1960*). *Heit (1968)* recommended testing of commercial seed lots, particularly Japanese rose seeds imported from Japan. Test conditions, following stratification, were: artificial light, 50 to 86°F alternating daily, and 14 to 28 days.

Stratified seed should be sown in early spring (*Schumacher 1962*). Fresh, cleaned seed can be sown in the fall, shortly after ripening, but should not be allowed to dry out before sowing (*Heit 1968*). For swamp rose, *Edminster (1947)* suggested a sowing rate of 6 ounces of seed per 100 square feet, covering the seeds with soil and mulch, and thinning to 25 plants per square foot. He estimated output at 10,000 usable plants per pound of cleaned seed and recommended outplanting of 1-0 stock, or when the plants were about 6 inches tall x $\frac{1}{8}$ inch caliper. Prairie rose output was given as 7,000 usable plants per pound of seed (*Swingle 1939*).

Seedlings started in a greenhouse should be

moved out by the end of May, to avoid overheating (*Morey 1960*). Seedlings can be transplanted to their permanent locations at the end of the first growing season, but if held until 2 years old, they should be top-pruned when outplanted (*Edminster and May 1951*).

Vegetative reproduction is a reasonable alternative to use of seed because nearly all roses propagate easily from cuttings of young wood (*Chapman 1947c*). Hardwood cuttings may be taken in late fall or winter. Basal and terminal cuts are made 6 to 8 inches apart, immediately below and above a node. Remove all buds except the one at the top node (*Adriance 1939*). If the winters are severe, plant the cuttings in cold frames with sand, sandy loam, or in some cases peat or a mixture of peat and sand. If winters are mild, place cuttings directly into nursery rows in the field.

Softwood cuttings, 6 to 7 inches long, may be taken in the spring or early summer. Remove only the basal leaves, plant the cuttings 3 inches deep, shade them until rooted, and water frequently. Gradually remove the shade after 10 to 14 days. Plant in April or May in the South, or in July or August in the North.

According to *Doran (1957)*, among prairie rose softwood cuttings, those with a heel rooted better than those without a heel. Indolebutyric acid (IBA) increased rooting in various roses. Success of summer cuttings of Japanese rose was improved by IBA (2.5 mg per liter for 24 hours, or 2 mg per gram talc). Dormant cuttings of Japanese rose also responded to IBA (5 to 10 mg/liter for 24 hours, or 2 mg/gram in talc). The temperature should be above 60°F.

In the nursery, roses are highly susceptible to diseases, and control is important. The first step in treatment is to prune out the diseased area. Powdery mildew may be treated with the following, all of which were equally effective: Karathane, Acti-dione P.M., folpet spray, or Copper Oleate (*Deep and Bartlett 1961*). *Garrett (1967)* recommended one tablespoon wettable powder of folpet per gallon of water. Spraying is always more effective than dusting.

Blackspot is another serious fungus disease of roses, except that Japanese rose tolerates it (*Buck 1964*). Blackspot can be controlled

with folpet (*Jacklin et al 1966*) or maneb (*Garrett 1967*). And good control was reported for combinations of folpet or Aramite with Santomerse, Tween-20, or DuPont spreader-sticker (*Palmer and Henneberry 1961*).

Control of weeds in the nursery is important to maintain proper growth of rose plants. The herbicides diuron and simazine were recommended (*Schneider 1959*), but dalapon stunted Japanese roses (*Taylorson and Holm 1958*).

MANAGEMENT

Some of the recommendations for establishing Japanese rose (*Edminster and May 1951, Zorb 1966*) may apply as well to other roses. Planting locations should be prepared in advance by plowing a double furrow or scalping 1-foot-square spots. Spacing between rows should be about 8 feet, and within rows should be 1 to 2 feet for hedges, 2 to 3 feet for road-banks, and 3 to 4 feet for woods borders. Fertilizer such as 5-10-5 should be applied at about 1 pound per 40 feet of row, and the plants should be side-dressed during the second year with nitrate of soda or equivalent, at the same rate. Machine cultivation is usually not practical for the roses with sprawling growth forms, but weeds can be controlled by spreading granular simazine with a cyclone seeder at about 2 pounds per acre. Apply the herbicide soon after planting the roses and repeat in the second spring.

Although Japanese rose does excellently in open woodland, it has often proved to be an unmanageable pest. It may spread rapidly in idle and unmanaged areas and in unmowable

pastures and fence rows (*Lloyd and Eley 1955*). It often produces a fence 10 to 15 feet wide, difficult to grub out or to pull out with a tractor and chain (*Dickey 1960*). Japanese rose has been reported to reduce the yield of corn by as much as 25 percent in rows next to a hedge (*Labiskey and Anderson 1965*).

To protect the layman, a Japanese rose policy was adopted in 1962 (*Ohio Agricultural Experiment Station 1962*). In essence it was decided not to use the species within 3,000 feet of any of the following: permanent unmanaged pasture; open woods used for timber production; Christmas tree plantings; idle land; and other areas not under management.

Where roses outgrew their bounds they may be difficult to control because all species can regenerate from remnants of their canes (*Fletcher and Talbert 1960*). Spraying with a herbicide may give effective control, particularly with older plants, if spraying is done in the latter half of May or in June (*Oregon Agricultural Progress 1958*). Japanese rose has been controlled with picloram, 2,3,6-TBA, or dicamba (*Scott 1965*), and with Tordon (*picloram*) at the rates of 1 to 3.2 pounds per mile of fence or 0.8 to 2.4 pounds per acre (*Corzart 1965*). In a herbicide manual, Japanese rose was rated susceptible to either monuron or 2,3,6-TBA; and intermediate in susceptibility to either silvex or 2,4,5-T. No comparable information for the other roses discussed here was given. But for several other native species, control was generally better from use of 2,3,6-TBA; monuron; or 2,4,5-T than from 2,4-D; MCPA; simazine; BMM; or silvex (*Dunham 1965*). Some results of applying herbicides by helicopter were reported by Friesen (*1961*) and Engel (*1964*).

SASSAFRAS

Sassafras albidum (Nutt.) Nees

Also called Ague Tree, Cinnamon Wood, Common Sassafras, Gumbo File, Mittenleaf, Red Sassafras, Saloop, Sassafac, Saxifras, Smelling Stick, and White Sassafras.

By Tom S. Hamilton, Jr.

*University of Massachusetts
Amherst*

RANGE

The center of the range is about at the Kentucky-Tennessee border. Edges of the range are southwestern Maine to New York, extreme southern Ontario, central Michigan and Illinois, Missouri, eastern Oklahoma and Texas, and central Florida. Sassafras is no longer found in southwestern Wisconsin, but is extending its range northward within Illinois.

HABITAT

Within the range of sassafras, average annual rainfall is about 30 to 55 inches. Of this, 25 to 30 inches fall during the effective growing season, April through August. At the northern limits of the range, the annual snowfall is 30 to 40 inches, while at the southern limits there may be practically none. The average frost-free period is 160 to 300 days. In January the average temperature is 20°F in the northern part of the range and 55°F in the south; the average July temperatures vary from 70 to 80°F. The altitudinal limit in the southern Appalachians is about 4,000 feet (*U.S. Forest Service 1965*). Sassafras generally

prefers a warm and sunny location in the north and may be killed if not well protected from extremes of winter weather.

Sassafras is found on practically all the soil types in its range, including those that are dry and infertile. However, the best stands are found in open woods on moist, rich, well-drained, sandy loam soils. The optimum soil pH was reported as 6.0 to 7.0 (*Spurway 1941*). On the Lake Michigan dunes of Indiana, sassafras grows on pure shifting sand. It is also found on poor gravelly soil and clay loams.

Sassafras is usually found as scattered individual trees or in small pure stands, and is usually in the dominant overstory. It is also found in the understory along edges of mixed woods, in the open along roadsides, in old fence rows, and in abandoned fields. Scattered trees of the species are found in many forest types such as oak-hickory, oak-pine, cypress-tupelo-sweetgum, and longleaf-loblolly-slash pine.

Common associates include flowering dogwood, elms, eastern red-cedar, American hornbeam, eastern hophornbeam, and pawpaw. In older stands sassafras is also found with ash

and sugar maple. On poorer sites, especially in the Appalachian Mountains, sassafras is also associated with black locust, red maple, and sourwood. At the northern edge of its range it is found in the understory of aspen and pin oak stands (*U. S. Forest Service 1965*).

Sassafras is often a pioneer species on abandoned fields and on dry ridges and upper slopes, especially after fire. It seems destined to continue to increase its range.

LIFE HISTORY

Individual sassafras trees bear either male or female flowers, and the buds of female flowers are much larger than those of males. The flowers bloom in early spring as the leaves start to unfold. Blossoms are greenish yellow, about $\frac{1}{4}$ inch across, and develop in drooping, few-flowered clusters. Fruits ripen in August to October. They are oval, one-seeded, dark blue, spicy drupes $\frac{1}{3}$ to $\frac{1}{2}$ inch long and are borne on erect bright red stems (*U. S. Forest Service 1948, 1965*).

Fruit-bearing begins as the trees approach 10 years of age and is greatest on 25- to 50-year-old trees. On bearing trees, good crops ordinarily occur at 1- or 2-year intervals. But a survey in the Ozarks showed that only 10 percent of the sassafras bore fruit. The proportion bearing was greater on plots in the 20- to 39-percent crown-cover class than in any other class (*Murphy and Ehrenreich 1965*). Fruit crops are usually lighter northward than near the center of the range (*Hosley 1938*).

Fruits collected in Mississippi had an exceptionally high fat content, 47 percent, and contained more total protein than the average among comparable woody plants (*Bonner 1971*). Other studies indicate that seed soundness runs about 35 percent (*U. S. Forest Service 1965*).

Birds are the principal agents of seed dispersal (*U. S. Forest Service 1948*), and some seeds probably are distributed by small mammals. But the effects on seeds of passage through animal digestive tracts are unknown. Seeds that have fallen, without intervention by animals, apparently lose germinability within 2 years. Under simulated natural storage conditions, samples from seeds that were 96 percent sound initially yielded only 12 per-

cent germination after 1 year and none after 2 years (*Clark 1962*).

Sassafras establishes from seed in new areas, but most of the subsequent reproduction is vegetative. The dense thickets often found in woods openings or in old fields are usually from root sprouts. On good sites where competition is not heavy, the sprouts may grow 12 feet tall in 3 years and sometimes are abundant. Where young sassafras is cut, sprouting from the stumps is often prolific (*U. S. Forest Service 1965*).

Sassafras varies in size from shrubs on poor sites, especially in the north and in Florida, to large trees with straight, clear trunks. It may attain heights of 100 feet or more and diameters of 6 feet on the best sites in the southern portions of its range. Most mature trees average 6 to 8 inches dbh. Average height is about 40 feet.

Sassafras in the Northeast has been ranked as intolerant of shade, but in the Southeast may be slightly more tolerant (*Forbes 1955*). It is relatively short-lived and transitory in wooded areas. If it becomes overtopped in mixed stands, it is one of the first species to die, even though it withstands light shade. In the understory along the edges of heavy stands it may persist but generally does not reach merchantable size. In open areas—and especially on abandoned fields—it is an aggressive tree and often is a vigorous invader where conditions are favorable.

USES

The bark, twigs, and leaves of sassafras are important foods for wildlife in some areas. The percentage to which the species may be browsed in several important vegetative types in the north is: cove hardwoods 40, oak-chestnut 40, and pine hardwoods 45 (*Shelford 1963*). Deer browse the twigs in the winter and the leaves and succulent growth during the spring and summer.

Palatability, although variable, is considered good throughout the range. In east Texas, sassafras is highly preferred; in Pennsylvania and western Virginia it is classed as an important source of food. In Ontario it is rated as having medium palatability with heavy browsing. In Arkansas the plants re-

ceive moderate to heavy use during the growing season (Leonard 1961). In some areas, sassafras is too palatable to survive long with heavy browsing. Browse users in addition to deer include black bear, beaver, cottontail rabbit, fox squirrel, marsh rabbit, and woodchuck (Martin et al 1951).

Sassafras fruit is available from August to October but generally is not an important source of food for wildlife other than bobwhite quail. Some of the other birds that utilize the fruit are wild turkey, catbird, flicker, crested flycatcher, kingbird, mockingbird, eastern phoebe, bluebird, robin, sapsucker, brown thrasher, gray-cheeked thrush, hermit thrush, olive-backed thrush, towhee, red-eyed vireo, warbling vireo, white-eyed vireo, pileated woodpecker, and yellow-throat warbler. Three flycatchers that subsist primarily on insects also eat this fruit. Mammals that eat the fruit include the black bear, raccoon, squirrel, and woodchuck (Martin et al 1951, Van Dersal 1938).

In addition to its values for wildlife, sassafras provides wood and bark for a variety of commercial and domestic uses. Sassafras tea is brewed from bark of the roots dug, usually, in the spring. The tea was once thought to be a cure for the ague. For this reason sassafras played an important part in exploration and settlement along the Atlantic Coast during the 16th century. Oil distilled from the bark is used for flavoring or scenting candies, medicines, soaps, and other items; and an extract has been used as an orange dye for wool.

Sassafras is also an attractive ornamental, particularly for use on fairly dry, infertile sites. The fall foliage is attractive, and the branching habit is picturesque (Hosely 1938). And sassafras is a good choice for restoring depleted soils in old fields. It was superior to black locust or pines for this purpose in Indiana and Illinois (Auten 1945).

PROPAGATION

Planting stock is available commercially from several nurseries in east-central states, and seed is provided by at least one dealer in Pennsylvania (Landscape Materials Information Serv. 1966, Mattoon 1959, Northeast Reg. Tech. Serv. Cent. 1971, U. S. Forest

Service 1972). Sassafras can be propagated from seeds or root cuttings collected locally.

Ripened fruit can be picked from the trees or shaken down onto drop cloths. Because birds often quickly consume the fruit (Fordham 1967), it should be collected as soon as ripe—when dark blue and soft. The pulp can be removed by rubbing the fruits over hardware cloth of a mesh fine enough to hold the seeds, and washing away the debris with water. The cleaned seed can be air-dried briefly but should not be allowed to dry out or heat before storage or sowing. Sassafras seed does not keep well (Fisher et al 1935, Clark 1962) and should be placed in sealed containers at 35 to 41°F if to be stored for more than a few days (U. S. Forest Service 1948). Seeds should not be frozen. Storage by stratification in sand or sand/peat at 35 to 41 F has also been suggested (U. S. Forest Service 1948). The number of cleaned seed per pound is about 4,000 (3,000 to 6,000). Samples of commercial seed have been about 85 percent sound.

Optimal treatments for seed propagation are unknown. Apparently seeds from the north are more difficult to germinate than those from the south (U. S. Forest Service 1948) and may require warm stratification or some equivalent followed by cold stratification (Franz L. Pogge, personal communication). The latter treatment only, at 41°F for 30 days, has been recommended for seeds from southern areas (U. S. Forest Service 1948). However, some lots of seed did not germinate in less than 80 days in the germinator, regardless of several storage conditions and pretreatments (Earl W. Belcher, personal communication). Since response may be slow at best, tetrazolium or other quick tests may be in order to determine viability of seeds in storage or stratification.

Sassafras has been field-grown successfully from direct fall seeding (Hosely 1938). Seed cleaning was considered unnecessary by Fisher et al (1935), but other investigators suggest that cleaned seed gives better results than whole fruits, and that sowing should be done late in the fall to prevent seeds from germinating too soon. This requires cold storage or cold stratification between seed collection and sowing dates (U. S. Forest Service 1948). How-

ever, some inconsistencies among these findings emphasize need for additional study of sassafras propagation from seed.

Seeds or whole fruits can be sown in drills 8 to 12 inches apart and covered with $\frac{1}{4}$ to $\frac{1}{2}$ inch of firmed soil. For fall seeding, a mulch of burlap, straw, or leaves, held in place by bird or shade screening, is desirable until after late frosts in the spring. Spring sowing of stratified seed can be done as early as soil conditions permit, and the beds should be kept moist until germination is complete. No shading is required. Later, the seedlings can be lined out in beds of moist, rich, loamy soil with leaf or litter mulch (*U. S. Forest Service 1948*).

Sassafras can be propagated fairly well from root cuttings, but not from stem cuttings (*Halls and Alcaniz 1965a, Pogge 1970*). Among six kinds of stem or root cuttings collected in Pennsylvania in the spring, best results were from large root sections, about 4 to 7 inches long, which already bore a live stem sprout. These cuttings were planted vertically in fine soil and the soil was kept moist. After 5 months, 80 percent of the cuttings had formed rootlets. The next best kind of cutting was a 4.5 to 6.5-inch section of a large root (0.4 to 1.0 inch diameter) planted horizontally (*Pogge 1970*).

Smaller root cuttings are used. Starting in December, usually, a section about $\frac{1}{2}$ inch long is placed horizontally in a small pot using a 2:1:1 mixture of peat, loam, and sand. The pot is filled to within 1 inch of its top, and the cutting is covered with $\frac{1}{2}$ inch of sand. Pots are then set in ashes or sand, watered well, and covered with paper. When well established, the plants are usually repotted and hardened off in cold frames (*Sheat 1963*). Alternatively, field-collected suckers can be lined out in rows and kept moist.

The best method of propagating sassafras in the field is by suckers. Suckers, often freely produced, can be dug and moved immediately; but it is better if they are cut around with a spade and allowed to remain in place for one season. This will stimulate sucker root growth. Most suckers are not well rooted and are rather difficult to transplant without careful

handling. Older plants are difficult to transplant because of their long taproots.

If direct-seeding in the field is tried, the best seedbed is a moist, rich, loamy soil partially protected by vegetative cover or litter. Cleaned seed or ripe fruit should be covered with $\frac{1}{2}$ inch of firmed soil. With favorable conditions, germination may occur in the same fall, but generally takes place in the following April and May. Young plants should be protected from browsing animals, but usually should not be shaded.

MANAGEMENT

In establishing new stands of sassafras, seedlings or plantings should be arranged so they will eventually form compact groups. Maintaining established stands is not difficult except where browsing removes more than one-fourth of the annual growth from young plants. Well-established stands in full sunlight are often dense enough to compete with other trees and shrubs, but other less desirable trees should not be allowed to overtop the sassafras.

Because natural reproduction from seed is usually sparse and erratic, regeneration from root suckers and stump sprouts is usually more reliable.

Fire may serve, accidentally or intentionally, in preparing sites for sassafras, but the species is highly susceptible to fire damage at all ages. Light fires kill seedling and sapling-size trees, and more intense fires injure large trees and provide entries for root and butt rots.

From New York to Florida the larvae of the wood-boring weevil *Apteromechus ferratus* can kill trees up to 10 inches dbh, and sassafras foliage is a favorite food of Japanese beetles (*Popillia japonica*). Serious damage by these insects should be controlled, but except for small local outbreaks, insect damage is relatively unimportant to sassafras (*U. S. Forest Service 1965*).

Sassafras can be rather easily killed or set back if such control is necessary. It is susceptible to burning and to many herbicides, including AMS, fenac, fenuron, fenuron TCA, monuron, 2,4-D, 2,4,5-T, and 2,3,6-TBA (*Dunham 1965, Gysel 1961, Nation and Lichy 1964*).

SERVICEBERRIES

Amelanchier Med.

Amelanchier arborea (Michx. f.) Fern.,

Amelanchier bartramiana (Tausch) M. J. Roem.,

Amelanchier X. grandiflora Rehd.,

Amelanchier laevis Wieg., and

Amelanchier sanguinea (Pursh.) DC.

Also called Juneberry, Serviceberry, Shadblow, and Shadbush.

By Joseph S. Larson

*University of Massachusetts
Amherst*

SPECIES

Botanists have not agreed on the classification of serviceberries, and land managers may not be able to distinguish among species. Accordingly, serviceberry is treated here as a group of similar species.

RANGE

Serviceberries grow throughout the Northeast.

Amelanchier arborea (formerly *canadensis*) ranges west to southern Ontario, northern Michigan, and eastern Minnesota, south to southeastern Nebraska, eastern Oklahoma, eastern Texas, Louisiana, and northern Florida.

Amelanchier bartramiana ranges north to Labrador and Newfoundland, and west to

northern Michigan and northeastern Minnesota. In the United States it is a several-stemmed shrub less than 10 feet high, but becomes a small tree in its northern range (Nova Scotia).

Amelanchier X. grandiflora is a large-flowered hybrid (*A. arborea X laevis*) ranging west to Missouri, south to Georgia and North Carolina, and is also found in cultivation.

Amelanchier laevis ranges west to Minnesota, eastern Kansas, Missouri, and Indiana, and south in the mountains to Georgia and Alabama.

Amelanchier sanguinea, which may reach proportions of a small tree 10 to 23 feet high, ranges west to northern Minnesota, northern Iowa, and southern Michigan, and is found in the mountains of western North Carolina (*Little 1953*).

Species in this genus grow in all of the 48

contiguous United States, Alaska, and the Canadian Provinces.

HABITAT

As a genus, serviceberry is acclimated to all the extremes found within the Region. Among the five species, *A. bartramiana* occurs at most northern latitudes and not south of northeastern Pennsylvania. *A. X. grandiflora* is found at latitudes from New Hampshire south. *A. sanguinea*, except for locations in mountainous North Carolina, remains north of New Jersey, and northern Ohio. *A. arborea* and *A. laevis* occur at all latitudes within the region, the latter preferring higher elevations at southern latitudes (Little 1953).

Serviceberry occurs most frequently in swampy to moist, slightly acid soils (pH 6.0 to 7.0) and along watercourses, although *A. laevis* and *A. arborea* will occupy dry upland sites. In Michigan *A. arborea* occupies sandy soils with pH as low as 4.0 (Hosley 1938). At the southern reaches of its range *A. bartramiana* occupies the higher altitudes (Pa.) as does *A. laevis* south of the Maryland-Pennsylvania region (Gleason and Cronquist 1963, Little 1953). Growth and fruit production are generally best in full sunlight, but the serviceberries tolerate shading.

The former oak-chestnut forest, now a grouping of red oak, chestnut oak, white oak, red maple and sourwood, with some Virginia and pitch pine included, supports serviceberry. In the northern coniferous forest, serviceberry is found with sheep-laurel, viburnums, Clintonia, and Labrador tea. It is a forest-edge species associated with aspen, chokecherry, hazelnut, rose, and birch (Shelford 1963). Old fields, coastal pine barrens, limestone hills, and barrens are other communities supporting serviceberry (Gleason and Cronquist 1963). On sand-flats along the Hudson River it is an invader in the shade of cottonwoods (McVaugh 1957).

LIFE HISTORY

The time of flowering is late March to May. The white flowers in terminal clusters often appear before the leaves, being among the earliest woodland trees and shrubs to produce

showy flowers. The fruit ripens, depending on the species, from late June to August. In several species the fruit is sweet and juicy, while some are small and dry (U. S. Forest Service 1948).

Information about seed production is sparse except for results of a West Virginia study in which 20 serviceberries averaging 3.2 inches in stem diameter were observed during 4 years. The crop failed in one year. Average fruit yield per plants was 2.4 quarts, and the fruits persisted on the plants until August 1. More than 70 percent of the plants bore some fruit except in the crop-failure year (Park 1942).

Seed production per plant is otherwise unknown. The numbers of seed per pound vary from 50,000 to 113,000, with an average of about 83,000. Small abortive seeds are numerous and are not included in these figures (U. S. Forest Service 1948).

Seed dispersal, almost entirely by animals and birds, usually takes place about as soon as the fruit ripens (U. S. Forest Service 1948). Sowing may be done on open ground in the spring, summer, or fall (Kains and McQuesten 1951), or seeds may be stratified and sown in the spring or sown in the nursery and transplanted (U. S. Forest Service 1948).

Serviceberry reproduces from seeds, from cuttings taken in the fall or spring, or from suckers (U. S. Forest Service 1948).

USE BY WILDLIFE

Twigs and foliage may constitute 1/2 to 2 percent of the diet of white-tailed deer; fruit and buds may comprise 1/2 to 2 percent of a ruffed grouse's diet; and the fruit, bark, and twigs may be 2 to 5 percent of the diet of the eastern fox squirrel. Many song birds and small mammals eat the fruits; and turkey, beaver, skunk, red fox, moose, eastern flying squirrel, raccoon, black bear, cottontail rabbit, and eastern red squirrel are known to consume the fruit, bark, or twigs (Bump et al 1947, Hosley 1956, Martin et al 1951, Van Dersal 1938). In the bear oak forest type it receives moderate use by white-tailed deer (Bramble and Goddard 1943).

Chemical analysis of *A. canadensis* fruits (Wainio and Forbes 1941) and *A. laevis* twigs (Bump et al 1947) have been reported.

The spring flowers give serviceberry an aesthetic value equal to its wildlife food value.

PROPAGATION

Though seed and stock are available commercially, it is doubtful that the cost can be justified for wildlife purposes alone. Cuttings, taken from vigorous specimens in the spring or fall, or suckers may be a more practical source for small-scale wildlife plantings. Root cuttings and softwood cuttings 3 to 6 inches long root most readily, and use of bottom heat and root hormone treatment have been recommended (Harris 1961). Commercial seed is over 90 percent pure and soundness averages about 80 percent (U. S. Forest Service 1948).

Optimum seed-storage conditions are unknown, but dry storage in sealed containers at 41° F. has been successful. Seed dormancy can be overcome partly by low-temperature stratification and scarification. Immersion in concentrated sulfuric acid for 30 minutes, combined with stratification, may be helpful.

Seeds are usually either fall sown, or stratified and sown in the spring in mulched beds. Drills of 25 viable seeds per linear foot, covered with ¼ inch of nursery soil are recommended. Nursery germination is about 40 percent; beds should be half shaded for the first year, transplanted after 1 year and field planted 2 to 3 years later (U. S. Forest Service 1948).

Seeds after-ripen more quickly and germinate better after dry storage and stratification at 34 to 41° F. for 3 to 5 months. After-ripening does not occur at 50° F., and no seedlings result when sown in a 70° F. greenhouse without previous cold treatment. Fall planting in a cold frame gives good seedling production (Crocker and Barton 1931). One test yielded 10,000 usable plants per pound of seed (Van Dersal 1938).

Serviceberry seed can be sown on open ground, but no data are available on success or procedure (Kains and McQuesten 1951).

MANAGEMENT

On intensively managed areas and in locations where the public has ready access, it seems worthwhile to protect and encourage serviceberry for combined aesthetic (flower) and fruit-producing values. It is apparently very susceptible to 2,4-D (Blaisdell and Muegler 1956) and may suffer heavy mortality when this herbicide is applied in control operations.

MISCELLANY

The taxonomic confusion among current authorities, at least in terms of name changes, makes use of the literature rather difficult if one is interested in the plant at the species level. It seems best to use Little (1953) as the basic authority on species names and ranges, though Gleason and Cronquist (1963) are more recent and differ markedly with Little in several respects. Little relies on the one monograph I have found on the group (Jones 1946), while Gleason and Cronquist appear to continue older designations.

Whichever authority is chosen, there is still difficulty with non-taxonomic references because one cannot be sure which system the author has used or whether he was competent to identify some of the more difficult species.

Infusions and tinctures of the dry flowers of *Amelanchier* are reported to be both a hypotensive and cardiotonic drug and a source of vitamin B₁₂ (Pisarev and Beisekova 1965). *Amelanchier* is a host for the cedar apple fungus, which produces leaf and fruit spots on apples (Van Dersal 1938) and a host to *Tympanis amelanchieris*, a minor fungus pathogen (Groves 1952).

COMMON SPICEBUSH

Lindera benzoin (L.) Blume
Formerly *Benzoin aestivale* (L.) Nees,
or *B. benzoin* (L.) Coult.

Also called Allspice Bush, Benjamin-Bush, Blume, Feverbush,
Pepperbush, Spiceberry, Spicebush, and Wild Allspice.

By Gene W. Wood

Pennsylvania State University
University Park

RANGE

Common spicebush occurs throughout most of the East, ranging north to southern Ontario and southwestern Maine. Along the southern portions of the Northeastern and Great Lakes States, the typical form overlaps the range of a variety [*L. b. pubescens* (Palmer and Steyererm.) Rehd.], which ranges southward to Florida and Texas (Fernald 1950, Gleason 1963b, Strausbaugh et al 1931).

HABITAT

Spicebush is found most often as a forest understory shrub in deciduous stands of advanced growth. It seldom forms dense communities, but may persist in forest openings (Van Dersal 1938). Its most common associate in the oak-hickory and mixed oak types is white oak. In coastal hardwood areas it may be found beneath swamp white oak. In the northern hardwood type, sugar maple, red maple, beech, sweet birch, and yellow birch most often form the overstories where this shrub grows. In western New York spicebush is commonly found in beech-American elm as-

sociations. In northern New Jersey, spicebush uniformly occurred in the most mesic (moist) sites, exemplified by ravines and north-facing slopes, and outranked all other shrubs and vines in this characteristic (Davidson and Buell 1967).

Typically, spicebush grows best on shaded, moist to well-drained sites in damp woods and along streams. The most favorable soils are fairly moist throughout the year, relatively fertile, high in organic matter, and moderately acidic (Van Dersal 1938). The optimum pH range is about 4.5 to 6.0 (Spurway 1941).

LIFE HISTORY

The yellow to greenish-yellow flowers appear as early as March or April in some parts of the range and always before leaf-bud break. The flowers occur in dense clusters at the nodes of the last year's shoots. A fleshy, scarlet drupe, approximately 0.4 inch long, is produced from each flower and ripens in September to October, or earlier in the south (Van Dersal 1938). One oval seed is contained in each fruit. The seed is light violet-brown with

flecks of darker brown (*U. S. Forest Service 1948*). Spicebush seed closely resembles that of sassafras (*Martin and Barkley 1961*). Three criteria that may separate the two are: sassafras is slightly shorter, the seed coat of sassafras is twice as thick, and sassafras is a solid dark brown while spicebush is mottled.

Seed production with respect to age is not well documented. Spicebush fruited for the first time at 3 years of age, among wildlings under little or no shade, in Connecticut (*Spinner and Ostrom 1945*). The shrub is not a heavy seed producer at any age, but older individuals seem to be better producers than young ones, and those exposed to full sunlight or light shade commonly produce better than those under dense cover. One hundred pounds of fresh fruit yields 15 to 25 pounds of cleaned seed. The number of cleaned seed per pound is 4,500 to 4,600 (*U. S. Forest Service 1948*).

Spicebush reproduces from seed, sprouts, and suckers; the latter two are the most common under natural conditions. Reproduction from seed will most likely occur where the overstory is removed sufficiently to warm up the damp soil that the plant requires. Increases in sprouting and suckering also occur under these conditions, often resulting in dense clusters of stems.

Growth will usually be best under light shade and on warm but very moist sites. Height growth rates under optimum conditions are not documented, but probably are about 12 to 24 inches per year in the early years. Spicebush may attain a height of 15 to 16 feet, but this is unusual in northern areas where mature plants generally range from 4 to 8 feet tall.

Spicebush is highly shade-tolerant, almost always being found under a canopy of some type. It is not an invader of openings such as old fields, and is a poor competitor for the better sites.

USES

The leaves and shoots are sometimes browsed by deer, usually as a pastime food. They are not preferred or staple deer foods in central Pennsylvania or western New York. The fruits are eaten by many birds, including

ruffed grouse, wild turkey, ring-necked pheasant, bobwhite quail, catbird, crested flycatcher, eastern kingbird, robin, graycheeked thrush, hermit thrush, and red-eyed vireo. The veery and wood thrush are particularly fond of spicebush fruits (*Martin et al 1951*). Because of its usual sparse growth habit, spicebush provides little in the way of cover for wildlife.

The aromatic bark of spicebush is said to have medicinal value for treatment of dysentery, coughs and colds, and as a vermifuge (*Krochmal et al 1969*).

PROPAGATION

Seeds are available at few supply houses, but may be available from Forestry Associates, Box 1069, Allentown, Pennsylvania. Seeds ordinarily lose viability quickly. Storage life may be lengthened by omitting the customary drying (*Swingle 1939*) and keeping seeds in sealed containers in a refrigerator or cold room (*U. S. Forest Service 1948*).

Spicebush seeds can be stratified to activate the dormant embryo. Stratification at 77°F for 15 to 30 days followed by 34 to 41°F for 90 to 120 days has been recommended (*U. S. Forest Service 1948*). Nearly as good germination resulted from stratification at 41°F for 120 days (*Barton 1939*).

The seed may be sown in the fall or spring. When fall sowing is done, the seed should be mulched over winter and the mulch removed in the spring. In areas of severe winter temperatures, the seed should be stratified below the frost line in the fall, and removed and sown in the spring. All planting should be done on moist soils of high organic matter content.

Cuttings ordinarily do not root easily (*Hottes 1931*), but spicebush is sometimes propagated from cuttings of half-ripe shoots taken in September (*Doran 1957, Osborn 1933*).

Field planting of spicebush is not reported in the literature. Presumably, plants can be propagated in the field directly from seed as well as from nursery stock. Field planting of seedlings will probably meet with greatest success on moist partially shaded sites.

MANAGEMENT

The main management objectives for this shrub would be as a food source for song birds and for landscaping. Management for browsing species of animals would probably not be worthwhile. For decorative purposes, the yellow flowers are attractive in early spring before the leaves open, and the red fruit and clear yellow foliage are showy in early fall (*Kammerer 1934*).

The species will be most responsive to a thin overstory canopy that results in diffuse

light conditions and maintenance of high soil moisture. Spicebush can be produced in full sunlight, as on clearcut areas, so long as the moisture is adequate. Attempts at production on droughty unprotected sites will most likely fail.

Foliar as well as stump applications of ammonium sulfamate, 2,4-D, or 2,4,5-T will control this shrub, but it is resistant to amitrole (*Dunham 1965*). Several of the pelleted herbicides—fenuron, picloram, and dicamba—may also be used effectively.

SPIREAS

Also called Meadowsweet and Pipestem.

BROADLEAF MEADOWSWEET, *Spiraea latifolia* (Ait.)
Borkh.

DWARF or CORYMBED SPIREA, *Spiraea corymbosa* Raf.

HARDHACK SPIREA or STEEPLEBUSH, *Spiraea tomentosa*
L.

NARROWLEAF MEADOWSWEET or PIPESTEM, *Spiraea*
alba Du Roi

VIRGINIA SPIREA, *Spiraea virginiana* Britt.

By Earl L. Core

West Virginia University
Morgantown

RANGE

About half a dozen kinds of native spirea occur in the Northeast. Of these narrowleaf meadowsweet or pipestem is by far the most common and has the widest range, extending from southwestern Quebec to North Carolina and westward as far as northern Missouri to Saskatchewan. Virginia spirea is the rarest, occurring in sporadic colonies from West Virginia south to Georgia (Clarkson 1959, Gleason 1963b, Strausbaugh and Core 1953). Introduced species may escape from cultivation.

HABITAT

Virtually all climatic zones represented in the Northeast include one or more of the spireas. Spireas grow well on a variety of soils. Narrowleaf meadowsweet occurs in wet meadows and swamps, often forming extensive

thickets in glady regions in the mountains. Hardhack or steeplebush is also found in mountain swamps, usually at somewhat higher elevations. Dwarf and broadleaf spirea, on the other hand, are more likely to be found on dry, rocky soil in mountain woods or old fields. Most species occur in neutral soil, but hardhack appears to prefer acid soils (Laurie and Chadwick 1931:79, Wherry 1957).

Narrowleaf meadowsweet forms part of a shrub community including alders, willows, and silky dogwood. Southward this community may be succeeded by elms, maples, white ash, and black cherry; northward by larch, birches, aspens, black ash, and conifers.

LIFE HISTORY

The white or pink flowers are usually numerous. Flowering occurs mostly in June and July, but may extend as late as September.

Pollen is carried by insects, chiefly bees. The fruit is a dry capsule, with two or several seeds, ripening in late summer. It is not known at what age seed-bearing begins, but it is quite likely at less than 10 years.

Published information about growth rates or natural methods of regeneration could not be found. Growth of narrowleaf and broadleaf meadowsweet is more vigorous in full sunlight than in shade. The other species appear to do better in some shade. Meadowsweet (*S. alba*) is slowly replaced by taller plants, except on the wettest sites.

USES

Deer browse meadowsweet and perhaps other species, but the plants are low in preference. Hardhack is apparently ignored by white-tail deer in Massachusetts (*Van Dersal 1938*). Other observed feeders are ruffed grouse and cottontail rabbits. Westward, in the Great Lakes region, prairie chickens eat the seeds and browse on buds and leaves (*Martin et al 1951*). Spireas are locally important as cover for cottontails, and, along with alders and willows, they are a common part of woodcock habitat.

Indians and early settlers used the stems of meadowsweet for pipe stems, whence the name pipestem, widely used in southern West Virginia (e.g. Pipestem State Park, in Summers County).

PROPAGATION

Many kinds of spireas are available for planting, but culture methods are more or less similar. All are easy to move and to grow. They need no special types of soil, although some do best in swamps while others prefer

drier soil. They thrive in sun and some will grow well in light shade (*Zucker 1966*). There are no particular insect or fungus pests.

Propagation is usually by cuttings, both softwood and hardwood. Leafy softwood cuttings made in summer and rooted under high humidity usually succeed; treatment with one of the root-promoting substances is beneficial. These root hormones increase the percentage of cuttings that form roots, as well as the number and quality of roots, thus ensuring uniformity of rooting. The presence of leaves on softwood cuttings greatly aids in root development. Some species of spirea can be started readily by hardwood cuttings planted in early spring (*Doran 1957, Hartmann and Kester 1968*).

Spireas may also be propagated by seeds planted in nursery beds in spring.

Meadowsweet and hardhack are recommended as excellent and good respectively, for planting for roadside and wildlife use in Wisconsin (*Natural Resources Committee 1967*).

MANAGEMENT

There is a lack of information about the ecology and management of this genus. When the editors polled biologists to determine what plants should be included in this publication, the spireas were ranked as moderately important for cover throughout northeastern North America. Only in Maine, Rhode Island, and Delaware were spireas considered of no importance. Despite this, there apparently has been no direct management for the spireas. Spireas can be controlled with the herbicides diuron, simazine, and 2,4,5-T applied according to the manufacturer's recommendations (*Dunham 1965*).

SUMACS

SMOOTH SUMAC, *Rhus glabra* L. Also called Common Sumac, Pennsylvania Sumach, Scarlet Sumac, Shernoke, Upland Sumach, and Vinegar Tree.

STAGHORN SUMAC, *Rhus typhina* L. Also called Hairy Sumac, Velvet Sumac, and Vinaigrier.

By Hanley K. Smith

Michigan State University
East Lansing

SPECIES

The species are staghorn sumac, *Rhus typhina*, and smooth sumac, *Rhus glabra*. An early technical name for staghorn, *R. hirta* (L.) Sudw., is common in older literature but is no longer valid. Smooth and staghorn sumac may hybridize, but this has not been demonstrated conclusively. Apparent intergrades are often recognized by the following names: *R. pulvinata*, *R. glabra* x *typhina*, *R. borealis* and *R. glabra* var. *borealis* (Little 1945).

RANGE

Smooth sumac is native throughout most of southern Canada, from southwestern Quebec to southern British Columbia, and all of the 48 contiguous United States. Staghorn sumac occurs naturally from Nova Scotia and the Gaspé Peninsula of Quebec south to North Carolina and west to southern Ontario, Minnesota, and Iowa (Barkley 1937, Little 1953). Both species have been planted widely for erosion control and as ornamentals.

HABITAT

The climate of the northeastern United States is not thought to be limiting to either species, but neither one extends far northward into Canada. Smooth sumac is the more widespread of the two species, probably because of its greater resistance to droughty conditions.

Both species are open-growing pioneer shrubs or small trees, and are usually found on well-drained soils. Typical growing sites include abandoned fields, roadsides, railroad right-of-ways, fence rows, burned or denuded areas, and young forest plantations (Boyd 1943, Clements 1920, Verts 1957). Smooth sumac is characteristic of the forest-prairie ecotone of the midwestern United States (Bray 1960), and both species are common on the abandoned farmlands of the northeastern United States and southeastern Canada (Hirth 1959). And optimum pH range of 5.0 to 6.0 has been reported for both species (Spurway 1941).

Associated species usually include the various old-field pioneer herbs, shrubs, and trees.

In Michigan these species include strawberry, blackberry, red oak, downy serviceberry, quaking aspen, and black cherry (Smith 1970). In Connecticut, blackberry, common juniper, eastern redcedar, northern bayberry, and red maple are common associates of smooth sumac (Hirth 1959). Sumacs are occasionally found growing under a recently closed forest canopy. This situation is usually temporary, as the vigor and reproductive capabilities of sumacs are hindered under shade conditions (Smith 1970).

LIFE HISTORY

In both species, plants usually bear either male or female flowers, not both sexes; but clones with both sexes on the same plant are found occasionally. Flowering occurs in June to July. The fruit matures in August to September (Gilbert 1959), and fruits commonly persist on undisturbed plants until the following summer. Both species are insect-pollinated.

The fruiting head is a compact cluster of red hairy drupes, each drupe about $\frac{1}{4}$ inch in diameter and containing one seed. Seed production is usually heavy, and each fruiting head may contain 100 to 700 seeds (Lovell 1964). The number and size of fruiting heads on a plant is variable, depending on age and vigor of the plant. A single acre of mature sumac may produce more than 3,500 fruiting heads (Smith 1970). The minimum fruiting age is usually 3 to 4 years (Smith 1970, Spinner and Ostrom 1945). The maximum fruiting age is unknown, but probably seldom exceeds 35 years on undisturbed sites. Among vigorous plants, fruit production is consistent and crop failure seldom occurs.

Sumac seeds are oval, smooth, 2 to 3 mm long, have an extremely hard seed coat, and exhibit mechanical dormancy (Heit 1967b). Enhanced germination of sumac seeds has been shown after their passage through the digestive systems of jackrabbits (Brown 1947), a ring-necked pheasant (Swank 1944), and quail (Krefting and Roe 1949); and it is assumed that seeds are disseminated in the droppings of various wildlife species.

Though invasion of new areas is by seeding, established sumac reproduces primarily from root sprouts. Typically, both smooth and staghorn sumac grow in a circular clone, the older stems in the center and the younger stems radiating outward. The lateral root system, from which the new stems arise, is elaborate, and has been reported to spread outward at a rate of about 3 feet per year. The clone begins to lose vigor at about 15 years, death of the aerial portions proceeding outward from the older center stems (Gilbert 1966).

Smooth sumac may reach a height of more than 12 feet, but is commonly less than 6 feet tall. Staghorn sumac is generally taller, with mature clones usually exceeding 6 feet in height. Plants in excess of 30 feet have been recorded, but these are considered uncommon (Smith 1970).

Sumac is characteristic of highly disturbed or denuded areas. Competition from other plants in these areas is negligible because unfavorable environmental conditions eliminate many competitors. In normal old-field succession, sumac fails to compete successfully with invading tree species and is seldom found growing under a closed forest canopy. The plants may also be adversely affected by a lack of available water, resulting from intense root competition or low rainfall (Weaver 1919).

Sumac is of limited economic importance and, consequently, reports of its diseases are rather uncommon in the literature. Several sumac species are known to be infected by fungi of the genera *Pileolaria*, *Fusarium*, *Cryptodsporthe*, *Physalospora*, *Verticillium*, and *Sphaerotheca* (Pirone et al 1960). A fungus of the genus *Pythium* commonly infected seedlings raised in the laboratory (Lovell 1964). In Michigan, the mite *Eriophyes rhois* and the moth *Holcocera chalcofrontella* have been observed to cause extensive damage to the foliage and fruit, respectively, of both smooth and staghorn sumac (Smith 1970).

USES

Ring-necked pheasants, bobwhite quail, wild turkey, and about 30 species of song birds include sumac fruit in their diets (Martin et al 1951). Sumac fruits are eaten by

many upland game birds, but are known to be important only in the winter diets of the ruffed grouse (*Bump et al 1947*) and the sharp-tailed grouse (*Ammann 1957*). The hard seeds of sumac sometimes function as grit for ruffed grouse (*Edminster 1947*). Fox squirrels (*Packard 1956*) and cottontail rabbits (*Hickie 1940*) include sumac bark in their diets during winter.

The fruit and stems of sumac are important winter foods for white-tailed deer throughout the eastern United States (*Banasiak 1961, Hosley and Ziebarth 1935*). In northern Michigan, sumac fruit and stems are heavily browsed by deer from October to March, the most intense browsing occurring in December and January (*Smith 1970*). When a fruit is browsed, the entire inflorescence is eaten. Browsing of stems, by contrast, usually consists of eating the outer 2 to 3 inches of the twig. Vigorous stands of sumac may produce in excess of 120 pounds (oven-dry weight) of fruit and stem browse per acre (*Smith 1970*).

The proximate analyses of the stems and fruit of smooth and staghorn sumac collected in Michigan indicate little difference in nutritional composition between species. Sumac was low in crude protein, high in ether extract, and similar in gross energy as compared to three other common deer browse species: northern white-cedar, jack pine, and bigtooth aspen (*Ullrey et al 1964; Ullrey et al 1967*). The following analyses are expressed on a fresh-weight basis (*Smith 1970*):

Item	Smooth sumac		Staghorn	
	Stem	Fruit	Stem	Fruit
Percentage composition:				
Dry matter	59.29	94.06	56.85	94.06
Cell-wall constituents:	25.22	53.59	22.98	49.77
Cellulose	12.57	21.68	11.80	18.88
Hemicellulose	5.24	14.05	4.60	15.23
Lignin	7.41	17.86	6.58	15.66
Cellular contents:	34.07	40.49	33.87	44.69
Soluble carbohydrates	21.01	18.10	20.61	22.83
Crude protein	3.45	5.24	3.85	5.01
Ether extract	6.54	13.80	6.22	13.89
Ash	3.08	3.35	3.10	2.96
Gross energy (kcal/g)	2.83	4.71	2.72	5.00

Sumacs offer very little winter cover for wildlife. Because they are often the largest and most common woody plants in old fields or forest openings, they provide spring and summer wildlife cover. However, they are not

important cover species and should not be established for that purpose.

Since both species have attractive fall foliage and persistent fruits, they are recommended as ornamental shrubs, particularly for dry, open sites where there is room for the plants to spread (*Holweg 1964, Zucker 1966*). Smooth sumac may be slightly better than staghorn for stabilizing dry sandy banks, screening, or roadside uses (*Wisconsin Conservation Department 1967, Zucker 1966*).

Sumac is also a source of tannic acid, although commercial production for this purpose is limited to Asia and Europe. Preparations of the fruits are used in folk medicines. Common uses include astringents, antidiuretics, and tonics (*Krochmal et al 1969*).

PROPAGATION

Seeds of both species are commercially available from a few suppliers. However, large quantities of seeds can be harvested readily from wild stock from September to December, as each fruiting head may produce more than 500 viable seeds.

Yields of cleaned seed per 100 pounds of fruit have been reported to be as low as 14 pounds (*Smith 1970*) and as high as 50 pounds (*U. S. Forest Service 1948*). The average number of cleaned seed per pound of smooth sumac has been reported to be as high as 69,000 (*Krefting and Roe 1949*) and as low as 46,000 (*Smith 1970*). The number of seeds per pound of staghorn sumac has been reported as 53,000 (*Krefting and Roe 1949*) and 60,000 (*Smith 1970*).

Seeds harvested in the field are encased in a dry, leathery pericarp. To extract large numbers of seeds, the fruits should be dried for 3 days at 110°F, placed in a cloth bag (½ pound of fruit in a 10 x 16-inch bag), and vigorously pounded against a hard surface for about 2 minutes. Motorized grain-threshing equipment does not work as well. The contents of the bag should then be placed in a tray of water and stirred. The viable seeds will sink to the bottom of the tray, while the defective seeds and debris will float. The water should then be poured off and the seeds retrieved, air-dried, and stored in sealed glass bottles. Over 90 percent of the seeds cleaned

in this manner germinated after proper scarification (*Smith 1970*). The seeds do not require special storage procedures and may be kept in sealed containers for a few years without loss of viability, but should be held at low temperatures if they are to be stored for many years (*Heit 1967b, Heit 1967e*).

Neither species of sumac shows internal seed dormancy, but both are extremely hard-seeded, and acid scarification is required to prepare them for germination (*Heit 1967b*). Optimum scarification time varies with the seed lots, but good results are usually obtained by placing the seeds in concentrated sulfuric acid for 1 to 4 hours (*Smith 1970*). Then, after washing and drying, no further pretreatment is necessary. It has been reported that up to 93 percent of properly treated sumac seeds will germinate within 10 days of planting (*Smith 1970*).

Sumac seed can be sown either in the fall or spring. Scarified seeds should be planted about $\frac{1}{4}$ to $\frac{1}{2}$ inch deep in moist sand or sandy loam. Very poor germination rates have been observed for seeds planted deeper than 1 inch (*Smith 1970*).

For the nursery, a seeding rate of 1 pound of seed per 100 square feet and a plant density of 10 per square foot have been recommended (*Edminster 1947*). Entire plants up to 1 year old may be transplanted with a high degree of success, if the soil surrounding the roots is kept intact (*Smith 1970*). Older plants may be transplanted with reasonable success, although more extensive root systems complicate the procedure. A recommended size for outplanting is 6 inches tall x $\frac{1}{8}$ inch caliper (*Edminster 1947*).

Field plantings may be established directly from seed. Scarified seeds covered with 1 inch of soil or less have the best chance of survival. Best results should be obtained by raking or disking an area broadcast at a rate of ten scarified seeds per square foot. But transplanting young plants from the nursery is a successful method of establishment, and is highly recom-

mended when the necessary manpower is available (*Smith 1970*).

Both species can be propagated from root cuttings taken in December. Staghorn sumac has been grown in England from late-summer stem cuttings (*Doran 1957*).

The bare, open, sandy soils on which sumacs may thrive often prove very droughty, and therefore may be lethal to young plants. For this reason, supplementary watering of newly established areas may be necessary during extended dry periods (*Smith 1970*).

MANAGEMENT

Staghorn and smooth sumac seem ideally fitted for establishment in abandoned fields, along roadsides, and on clearcut areas. They offer a valuable wildlife food, erosion control, and may be used to improve the appearance of recently disturbed or otherwise unsightly areas. Sumacs may be especially desirable in recently planted or newly cut conifer plantations and along forest roads.

A third, and perhaps the simplest method of propagation, involves rejuvenation through disturbance of established stands. Sumac often responds to disturbances such as plowing, fire, and cutting by sending up many young shoots from its root system. There are two situations when this response is especially useful. First, where the crown has grown beyond the reach of potential browsers. Cutting the tall stems will often promote root sprouting and thus restore available browse. Second, when a clone has begun to lose vigor and die. In this case, mowing or plowing may rejuvenate the clone, allowing it several more years of productivity. However, the magnitude of this response is proportional to the vigor of the clone (*Smith 1970*).

Sumac is difficult to destroy mechanically because of its prolific response to disturbance. However, the plants can be controlled by foliage sprays or other applications of various herbicides, notably D-T; 2,4,5,-T; AMS; fenuron; and 2,3,6-TBA (*Arend and Roe 1961, Dunham 1965, Egler 1949*).

SWEETFERN

Comptonia peregrina (L.) Coult.

By Sanford D. Schemnitz
University of Maine
Orono

RANGE

Sweetfern occurs throughout the Northeast, southward to northern Georgia and Tennessee, and westward to Manitoba, Minnesota, and parts of Indiana and Illinois.

HABITAT

The species tolerates a variety of conditions throughout the region. It is common on upland slopes where trees are sparse or absent (*Martin et al 1951*) and along roadsides and under powerlines. In Maine, sweetfern is often a major component of blueberry barrens and old fields. In Pennsylvania, sweetfern frequently invades burned-over areas and abandoned fields (*Grimm 1951*).

Optimum growing conditions for sweetfern have not been described, but good growth of the plant is often found on dry, well-drained, sterile, sandy soils. Sweetfern has root nodules, comparable to those on legumes and alders, which tend to enrich soil by fixing atmospheric nitrogen (*Ziegler and Huser 1963*).

LIFE HISTORY

The individual plant produces either flowers of only one sex or of both sexes. However each flower is unisexual, and the flowers appear in catkins clustered at the ends of the branches.

The male catkins are rather long and cylindrical; the female catkins are short and rounded. In winter the male catkins are prominent and erect.

The seeds are nutlets that mature in August and become available in September and October. They are contained in bur-like heads about $\frac{1}{2}$ inch in diameter. About 4 seeds or nutlets are found in each bur-like fruit. Each seed is about $\frac{1}{4}$ inch long, olive brown, and shiny. One hundred pounds of fresh burs will produce about 4 to 12 pounds of cleaned seed of about 4 percent soundness. Cleaned seed varied from 31,200 to 54,800 per pound. Germination rates were low (*U. S. Forest Service 1948*) in one test, but the reason was not investigated.

Mature plants are usually less than 3 feet tall but I found no information about growth rates. Much of the reproduction is via sucker growth from long underground stems. There is much variation in leaf form, with occasional compound leaves (*Berry 1906*). Sweetfern is intolerant of shading and usually grows best in full sunlight.

USE BY WILDLIFE

Sweetfern has long been considered valuable to wildlife for cover and browse (*McAtee*

1936). It was listed along with species commonly browsed by Maine deer in winter (*Banasiak 1961*). At Acadia National Park, Maine, 14 percent of the available twigs of sweetfern

had been browsed during the fall and winter by deer on 114 of 120 total plots.

The chemical composition of sweetfern, reported by three authors, is high in protein.

Authority	State	Date	Percent crude protein	Crude fiber	Fat	Percent N. free extract
Davenport (unpublished)	Michigan	3/8/37	13.3	22.1	5.6	55.7
Baird (1966)	Maine	8/10/65	9.7	14.6	6.5	67.0
Roop (1968)	Maine	Winter/66	10.8	—	—	—

Sweetfern buds, catkins and foliage are a very minor food of ruffed grouse throughout the region (*Edminster 1947; Martin et al 1951*). In extensive studies in New York in 1931-41, sweetfern was found as a trace in 0.002 percent of 1,632 grouse crops (*Bump et al 1947*).

PROPAGATION

I found no specific information.

MANAGEMENT

I found little information. Sweetfern thrived after 2,4-D and 2,4,5-T broadcast spraying of utility lines in Pennsylvania and New Hampshire (*Bramble 1968, Hodgdon 1958*). In contrast, good control was reported from eastern Maine where 2,4-D (2 pounds of ester per 100 gallons) was applied on blueberry fields (*Trevett 1960*). Ammonium sulfamate ($\frac{3}{4}$ pound per gallon) also controlled sweetfern among blueberries (*Smith et al 1947*).

Sweetfern sprouting vigor was increased by burning New Hampshire blueberry fields at 3-year intervals (*Smith et al 1947*).

MISCELLANY

Sweetfern is the alternate host of sweetfern blister rust (*Cronartium comptoniae*) a fungus that ranges from Nova Scotia south to North Carolina on hard pines. Jack pines are often attacked by the rust, trees less than 3 inches being girdled. The rust has been found in ponderosa pine plantations in Connecticut (*Boyce 1938*). Sweetfern is also the alternate host of the Saratoga spittle bug (*Aphrophora saratogensis*), which attacks pines in the East (*Boyce 1938*).

The leaves have been used as an ingredient in diet drinks and as a remedy for dysentery (*Billington 1949*). Sweetfern is also considered to be valuable for ornamental purposes (*U. S. Forest Service 1948*).

VIBURNUMS

MAPLELEAF VIBURNUM, *Viburnum acerifolium* L.

HOBBLEBUSH VIBURNUM, *Viburnum alnifolium* of authors,
not Marsh.

WITHEROD VIBURNUM, *Viburnum cassinoides* L.

NANNYBERRY VIBURNUM, *Viburnum lentago* L.

CRANBERRYBUSH VIBURNUM, *Viburnum opulus* L.

BLACKHAW VIBURNUM, *Viburnum prunifolium* L.

ARROWWOOD VIBURNUM, *Viburnum recognitum* Fern.

By James A. Rollins
Nasson College
Springvale, Maine

SPECIES AND RANGES

Viburnums are difficult to classify, and botanists have disagreed on some names. I have used the names given in the 8th edition of Gray's Manual (*Fernald 1950*), except that American and European cranberrybush are combined as one species (*McAtee 1956*) and simply called cranberrybush viburnum. Nomenclature used in much of the older literature may be confusing, particularly in regard to the forms whose names have included the word arrowwood. Table 1 shows some of the alternative common and technical names given in the literature, and the ranges of the seven species.

HABITAT

The viburnums included here are well adapted to the humid climate of northeastern North America (*Thornthwaite 1931*). Most species occupy nearly the entire climatic range of the Northeast except that cranberrybush and nannyberry grow mostly at higher elevations southward, and blackhaw is more typically a southern species. Arrowwood overlaps the range of southern arrowwood (*V. dentatum* L.) southward from Massachusetts Pennsylvania (table 1).

Blackhaw, mapleleaf, and witherod viburnums are often found on dry sites such as south-facing slopes (*Cantlon 1953*), ridge tops

Table 1.—*Viburnum* names, ranges, and growth habits

Preferred names and synonyms	Scientific names	Occurrence	Growth habit
MAPLELEAF V.: dockmackie, maple leaf arrowwood, possum-haw.	<i>V. acerifolium</i> L.	Quebec to Minnesota, south to Georgia and Tennessee; Dry or rocky woods.	Erect shrub, sometimes thicket-forming, to 6 feet.
HOBBLEBUSH V.: moosewood, tangle-legs, witch-hobble, bois d'original.	<i>V. alniifolium</i> of authors, not Marsh.; <i>V. grandifolium</i> Ait.; <i>V. lantanoides</i> Michx.	Prince Edward Isle to Ontario and Michigan, south to Tennessee, Georgia, and North Carolina; woods and cool ravines; moist, well-drained soils. Tolerates low pH.	Erect or sometimes trailing shrubs to 10 feet, rarely to 15 feet.
WITHEROD V.: wild-raisin, alister.	<i>V. cassinoides</i> L.	Newfoundland to Manitoba, south to Tennessee, Georgia and North Carolina; thickets, clearings, swamps, borders of woods; moist or dry soils.	Erect, sometimes tree-like shrub to 13 feet.
NANNYBERRY V.: blackhaw, sheepberry, sweet viburnum, wild-raisin, alister.	<i>V. lentago</i> L.	Manitoba to western Quebec, south to New England, New Jersey, Pennsylvania, Georgia; Ohio, Indiana, Illinois, northeast Missouri; South Dakota, Colorado, Wyoming. Borders of woods, streambanks. Tolerates low pH.	Erect, tree-like shrub with slender branches, to 33 feet.
CRANBERRYBUSH V.: Guelder rose, highbush cranberry, pimbina, pin-cushion tree, quatre-saisons de bois.	<i>V. opulus</i> L.; <i>V. americanum</i> of authors, not Mill.; <i>V. o. americanum</i> Ait.; <i>V. trilobum</i> Marsh.	Europe, north Africa, northern Asia, British Columbia to Newfoundland, south to Nova Scotia, New England, Pennsylvania, northern Ohio, northern Indiana, northern Illinois, northeast Iowa, South Dakota, Wyoming, Washington. Cool woods, thickets, shores, rocky slopes. Moist, well-drained soils.	Erect shrub, to 13 feet.
BLACKHAW V.: stagbush, sweethaw.	<i>V. prunifolium</i> L., <i>V. bushii</i> Ashe., <i>V. p. globosum</i> Nash	Texas, northern Florida, north to Connecticut, New York, Ohio, Michigan, Illinois, Iowa, Kansas. Thickets, borders of woods, streambanks, shores; moist or dry soils.	Erect shrub with rigid spreading branches, to 16 feet.
ARROWWOOD V.: smooth arrowwood.	<i>V. recognitum</i> Fern., <i>V. dentatum</i> Fern. (ed. 7), not L.	New Brunswick to southern Ontario, south to southern New England, Long Island, South Carolina, northern Ohio, Michigan. Damp thickets.	Erect bushy shrub, to 10 feet.

(*McIntosh 1959*), or dry sandy loams in upland situations (*Shreve et al 1910*). However, they are not restricted to dry soils. In Pennsylvania, mapleleaf viburnum grew on such contrasting sites as strip-mine spoil banks (*Bramble and Ashley 1955*) and the moist rich loam of a north-facing slope (*Harshberger 1919*). Witherod was reported growing along swamps and bogs in Maine (*Davis 1966, Hill 1923*) and Kentucky (*Braun 1950*) as well as on the moist soils of spruce flats and slopes in Maine (*Oosting and Reed 1944*).

Arrowwood, cranberrybush, hobblebush, and nannyberry are usually found on wet or moist but well-drained soils. Soil composition does not have much influence on the occurrence of these species, and soil pH is usually not critical. Hobblebush and nannyberry are perhaps the species most tolerant of low pH.

Viburnums are characteristic of the shrub layer in the hemlock - white pine - northern hardwood forest (*Hough 1936, Lutz 1930, Nichols 1935, Niering 1953*), the spruce-fir forest (*Davis 1966, McIntosh and Hurley 1964, Oosting and Reed 1944*), and the mesophytic deciduous forest (*Braun 1950*). They also occur as forest-edge, hedgerow, roadside, stream bank, and bog-edge plants. By providing food and cover in these situations they are most valuable for wildlife. Once established, they are able to maintain their position during successional changes in the forest because of their high degree of shade-tolerance. They were present under the dense cover of the early virgin forests (*Lutz 1930*), although overbrowsing can permanently remove them from such stands (*Gould 1966*).

LIFE HISTORY

Viburnums in the Northeast generally flower in May and June (table 2). Blackhaw flowers slightly earlier, in April to June, and withered a bit later, into July (*Bailey 1935*).

The small, white flowers are arranged in flat, rounded, or pyramidal clusters (cymes). The marginal flowers of the cyme are sterile in cranberrybush and hobblebush, and in some cultivated varieties of cranberrybush all of the flowers are sterile. The flowers of all species are attractive and make the plants desirable as ornamentals. Cranberrybush and hobblebush blossoms are the most showy.

The fruit is a fleshy drupe containing a thin flattened stone. Fruit size varies among species from $\frac{1}{4}$ to $\frac{3}{4}$ inch (table 2). Ripened fruits are dark blue or black in all species except the red-fruited cranberrybush. Ripening occurs most typically in late summer and early fall, but there is considerable variability among species and locations. The dates shown in table 2 are representative, but flowering and fruit ripening may occur a month or so earlier or later in some areas or years.

With the exception of hobblebush, I found no data about the yield of fruit or seed on a per-plant or area basis. For hobblebush, each fruiting stem yielded about 17 fruits, but the variation in yield from stem to stem was high (*Gould 1966*). However, since hobblebush normally occurs as a shrub layer under shade conditions that do not favor flower and fruit production, the yield of hobblebush fruit on a per-acre basis is low. Furthermore, in openings where flowering is enhanced, late spring frosts tend to kill the flowers and further reduce the

Table 2.—Viburnum flowering and fruiting characteristics

Species	Flowering	Fruit ripening	Seed dispersal	Color and size of ripe fruit
Mapleleaf	May-June	July-Oct	Fall	Purplish black, $\frac{3}{8}$ inch diameter
Hobblebush	May-June	Aug-Sept	Fall	Purple to black ¹ , $\frac{5}{16}$ inch long
Witherod	May-July	Sept-Oct	Fall	Blue to black, $\frac{1}{4}$ inch long
Nannyberry	May-June	Aug-Oct	Fall to spring	Blue-black, $\frac{1}{2}$ to $\frac{3}{4}$ inch long
Cranberrybush	May-June	Aug-Oct	Fall to spring	Orange to scarlet, $\frac{3}{8}$ to $\frac{1}{2}$ inch long
Blackhaw	Apr-June	Sept-Oct	Fall to spring	Blue-black, $\frac{5}{16}$ to $\frac{1}{2}$ inch long
Arrowwood	May-June	Aug-Sept	Fall-winter	Blue-black, $\frac{1}{4}$ inch long

¹Fruits are mature enough for germination when bright scarlet (*Gould 1966*).

Table 3.—Viburnum fruit and seed yields

Species	Number of dried fruits per pound	Pounds per 100 pounds of fruits	Cleaned seed		
			Thousands of seeds per pound	Low	Average
Mapleleaf	4,800	30	10.9	13.1	16.6
Hobblebush	7,580	43 ¹	—	11.5	—
Witherod	3,000	—	75.0	27.6	29.0
Nannyberry	2,200	9-50	2.2	5.9	12.4
Cranberrybush	5,500	6-33	9.4	13.6	17.8
Blackhaw	—	20-50	4.0	4.8	6.0
Arrowwood ²	—	25-30	14.6	20.4	32.6

¹Weight per 100 pounds of dried fruit.

²Species uncertain due to changes in names.

yield of fruit. An additional factor that may reduce the yield of fruit is the tendency for the flowers, immature fruit, and even the entire inflorescence to drop off if hit, brushed against, or otherwise disturbed.

The number of seeds per pound, the number of dried fruits per pound, and the yield in cleaned seed per 100 pounds of fresh fruit are given in table 3.

Seed dispersal in the viburnums is aided by birds and mammals. Various authorities attribute the dispersal of viburnum seed to birds, but no viable hobblebush seed was recovered after force-feeding it to various species of birds (*Gould 1966*). Small mammals were thought to be the most important dispersal agents for hobblebush seed. Specific information about the dispersal of seed for the other species was not found.

Viburnums may regenerate either from seed or vegetatively by root suckering, sprouting, or layering. Invasion of new areas is by seed followed by root suckering or layering of stems. In Connecticut, an almost pure stand of nannyberry, about 50 x 50 feet in size, resulted from the establishment of only a few seedlings followed by extensive root suckering (*Niering and Egler 1955*). Thus practically the entire community had a common root system. In a study in New York, hobblebush regeneration was mainly vegetative, especially by basal sprouting; and very few seedlings were found (*Gould 1966*). Hobblebush also readily produces layers from prostrate branches, which often remain attached to the main stem, forming loops. These loops fre-

quently trip the unwary traveler and are the source of the common names of the plant—hobblebush, tangle-legs, and witch hobble.

The viburnums vary considerably in height at maturity. Mapleleaf is the smallest, to about 6 feet, and nannyberry grows tallest, about 30 feet. Species reaching about 10 feet in height are arrowwood, hobblebush, and witherod; but hobblebush may grow as a low prostrate shrub, less than 5 feet tall. Blackhaw and cranberrybush are tall shrubs (table 1). Growth-rate information is scanty. Nannyberry in Connecticut was 15 to 18 feet tall at 26 years (*Niering and Egler 1955*).

Viburnums are characteristic of the shrub layer in the hemlock - white pine - northern hardwood forests, the spruce-fir forests, and the mesophytic forests of the Appalachians. They are well adapted to survival and growth under shaded conditions. Shade may be a requirement for optimum growth and development of arrowwood (*Hotts 1931*), hobblebush (*Gould 1966*), and mapleleaf viburnum. Since viburnums are also often found in forest edges, along hedgerows and right-of-ways as well as along the edges of swamps and bogs, they are capable of growth in full or nearly full sunlight. Characteristic of these sites are blackhaw, cranberrybush, nannyberry, and witherod. Viburnums are capable of forming relatively pure, closed stands either under a canopy layer or in the open, thereby excluding the regeneration of other species of plants. This has been reported for hobblebush (*Gould 1966*) and nannyberry (*Niering and Egler 1955*).

USES

Viburnums form a minor but important segment of the diet of many birds and mammals. The fruits are eaten by deer, beaver, rabbit, chipmunk, squirrel, mice, skunk, grouse, pheasant, wild turkey, and numerous species of song birds including the cardinal, cedar waxwing, and robin. The twigs, bark, and leaves are eaten by deer, moose, and beaver (Martin *et al* 1951).

Hobblebush is one of the major winter foods of the white-tailed deer in New York (Gould 1966, Townsend and Smith 1933, Webb 1959) and disappears rapidly when deer populations exceed the carrying capacity of the range. In Massachusetts, witherod is an important winter food of white-tailed deer, although other species of viburnum are also taken in lesser quantities (Hosley and Ziebarth 1935). Summer feeding by deer on hobblebush (Gould 1966) and arrowwood (Cook 1946) has been reported. The bark and tender stems of maple-leaf viburnum and arrowwood were preferred winter foods of the cottontail rabbit in central Massachusetts (Sweetman 1944).

In feeding tests of hobblebush seeds and fruits, the pulp was probably distasteful to small mammals, because they invariably consumed the cleaned seed first. Furthermore, samaras (fruit) of sugar maple were preferred over either cleaned seed or dried fruit of hobblebush (Gould 1966).

In Maine, grouse consume the fruit of arrowwood, cranberrybush, and witherod during the fall, but make little use of viburnums during the rest of the year (Brown 1946). They apparently do not eat the buds.

The nutritive content of hobblebush twigs (Silver and Colovos 1957) and seeds and pulp (Gould 1966) have been measured. The twig results indicate that, though palatability is high, protein content and protein utilization are low. Carbohydrate content and utilization are comparable to similar browse, but the ash fraction, which contains the essential minerals, was twice as high as in other browse species tested. The seeds and pulp have moderate protein levels and high carbohydrate levels, but low ash content. The differences between the nutritive values of the twigs and seeds are striking. Nutritive content values for arrow-

wood, nannyberry, and witherod show differences between the twigs and fruit similar to those of hobblebush, as well as differences between species (Bump *et al* 1947). But it is hard to evaluate these data because the plants were grown on different soils, under different climatic conditions, and probably under different stand conditions. All of these factors could affect the nutrient content of the plants and the distribution of nutrients within the plant.

Viburnums are an important component of forest-edge and hedgerow cover types that provide shelter and food for small mammals and song birds (Bump *et al* 1947). One authority made specific reference to the use of the hobblebush shrub layer by deer for concealment and by warblers for nesting (Gould 1966). Beaver use the larger stems of hobblebush in building their dams and houses (Bailey 1927).

Blackhaw, cranberrybush, hobblebush, and nannyberry are potentially useful as human food. In 1915 a cranberrybush plantation was established at Lee, Massachusetts, to provide stock for the selection and propagation of the most useful strains (Darrow 1924). The bark of the cranberrybush has medicinal properties, and that of hobblebush, although toxic, has been used to adulterate the more expensive cranberrybush bark (Younghen 1932, Younghen and Munch 1940).

The viburnums are widely used as ornamental plants, both for their showy flowers and for their fall foliage. Many commercial varieties of various species have been developed and are now on the market.

PROPAGATION

Seed or planting stock of all viburnums discussed here is available from commercial seedsmen and nurseries. Planting stock from commercial sources is likely to be too costly for large-scale wildlife-habitat plantings. However, seed is less expensive, and it is quite practical to either purchase seed or collect a supply locally, even if only a few hundred plants are desired. It should be possible and it is definitely desirable to find local, native stands of the desired species from which seed collections can be made. The advantages of this approach are many. First, plants grown

from local seed are likely to be better adapted to local growing conditions. Second, timing the seed collection to coincide with the proper developmental stage of the seed can save time and difficulty in the nursery. Third, the characteristics of the parent plants will be known, and selection for desired qualities will be possible.

Seeds of all species of viburnum can be stored successfully for a long time provided certain precautions are observed. Immediately after collection, the pulp should be separated from the seed by maceration and water flotation. The cleaned seeds should then be thoroughly air-dried, after which they can be placed in sealed containers and kept under refrigeration at 34 to 38°F. Seeds stored under these conditions have retained viability for 10 years (Heit 1967e). If only short-term storage is required, the seeds need not be cleaned. The whole fruits should be spread out and allowed to air-dry. This should be done as soon as possible after picking in order to avoid heating. The air-dried fruits can then be stored in sealed containers under refrigeration at 41°F or less. With this method, mapleleaf viburnum seed showed no loss in germinability over a 2-year period (U.S. Forest Service 1948).

In nature, germination is normally delayed until the second spring after seed ripening. Seeds of the viburnum species discussed here all seem to require a two-stage stratification process to break dormancy. The first stage is a warm stratification period either at a constant 68°F or alternating 50 or 68°F (night) to 86°F (day) temperature. During this period

the radicle emerges from the seed and begins growth. The second or cold stratification is carried out at 41 or 50°F and breaks the dormancy of the plumule (leaf bud), which will then begin to grow when the seed is returned to a higher temperature (Davis 1926, Giersbach 1937). The length of each stratification period is fairly critical and has not been worked out in detail. Suggested times are given in table 4 together with the recommended stratification media.

There are alternative methods for overcoming seed dormancy. The seed may be sown immediately after collection. Depending on nursery location, this may allow enough warm days to elapse for natural warm-stratification to take place before the onset of cold weather. The seed will then germinate the first spring. If not, then germination will take place the second spring as expected. For example, nannyberry seed and fruit sown on 7 October in Ohio gave a seedling yield of about 75 percent in the following summer (Smith 1952). Alternatively, seed or fruit can be stored over winter and sown the following spring. Arrowwood, blackhaw and mapleleaf viburnum seed planted on 1 May in New York gave fair to good yields in the next year. Cranberrybush, which has less dormancy-breaking requirements, gave high yields when sown as late as 1 July (Giersbach 1937).

The simplest and perhaps the most practical method is to let nature take its course. Sow the seed either in the fall or spring, and allow a full summer for radicle development. The next winter will provide the necessary

Table 4.—Viburnum seed treatments for breaking dormancy

Species	Medium	Stratification sequence				Data source
		First stage		Second stage		
		Temp. °F ¹	Months	Temp. °F	Months	
Mapleleaf	Peat	68-86	12-17	50	4	(Giersbach 1937)
Hobblebush	Peat	68-86	5	41	2 1/2	(Gould 1966)
Witherod	Sand	68-86	2	50	3	(U. S. Forest Service 1948)
Nannyberry	Peat	68-86	5	41 or 50	3-4	(Barton 1958, Giersbach 1937)
Cranberrybush	Peat	50-86	2	41 or 50	1 1/2-2	(Barton 1958, Giersbach 1937)
Blackhaw	Peat	50-86	7-9	41 or 50	1 1/2-2	(Barton 1958, Giersbach 1937)
Arrowwood	Peat	68-86	12-17	50	2 1/2	(Giersbach 1937)

¹The two temperatures given are for night and day within a daily cycle. A constant 68°F is about as effective as alternating temperatures for most species (Barton 1958).

cold period, and germination will take place the following spring. One advantage of this method is that the seed need not be handled after the radicle has emerged.

The seed may be broadcast sown directly on prepared seedbeds and mulched with sawdust (the practice at the Maine State Forest Nursery) or it may be sown in drills and mulched with straw (*U. S. Forest Service 1948*). The advantage of sawdust is that it does not have to be removed after germination begins. It may be necessary to hold sawdust in place with something like mulchnet or to replace it periodically. Straw mulch must be removed once germination begins, to reduce the risk of loss due to damping-off fungi.

The seedlings may require shade for proper development, although this will depend on the species and location. Shade was required for best growth of hobblebush seedlings in the second year (*Gould 1966*), but cranberrybush seedlings were successfully raised in Maine without shade. The seedlings should be ready for outplanting on properly prepared sites after one or two seasons of growth in the seedbed.

Viburnums can also be propagated from either hardwood or softwood cuttings and by layering. These are the methods used by commercial nurseries. Layering is likely to be expensive in man-hours while softwood cuttings require special equipment such as mist chambers or greenhouses. Hardwood cuttings require the least labor and equipment but will probably take an extra year as transplants in the nursery before being ready for field outplanting. More detail about vegetative propagation is available in nursery handbooks and technical journals (*Devisser 1967, Doran 1957, Hottes 1931, Klapis 1967*).

Viburnums prefer a moderately fertile, moist soil (*Bump et al 1947*) if they are planted in open fields. Hobblebush, mapleleaf viburnum, and nannyberry can tolerate fairly

acid soils (*Gould 1966, Niering and Egler 1955, Spurway 1941*). Information on the pH requirements of the other species is less definite, but neutral to slightly acid soils are recommended for viburnums in general (*Van Dersal 1938*). Survival and growth of the planting is likely to be highly correlated with the degree of site preparation. Scalping to remove sod should be considered the minimum preparation. If the planting is to be in an old field it may be possible to plow and harrow the land the preceding season. Since plantings for wildlife-habitat purposes are often arranged in long, fairly narrow designs, plowing and disking is more practical for this type of planting than if an entire field were to be planted. Grass can also be controlled by herbicides and growth retardants. Browsing by deer, rabbits, or livestock may be the chief obstacle to early development of the plantings.

MANAGEMENT

Once the plantings are established, little maintenance should be required. Though light grazing is beneficial, browsing by deer and cattle must be kept under control because the viburnums will be unable to maintain themselves in competition with other species if overbrowsed (*Bump et al 1947, Gould 1966*). Undesirable competing species can be eliminated or controlled by the selective use of herbicides employed as basal sprays. If browse production for deer is a management objective, it may be necessary to periodically cut back some of the taller species to keep them within reach.

Viburnums can be controlled with herbicides. Due to the growth habit of spreading by root suckers, a significant amount of flashback killing is possible. For this reason herbicides that are translocated throughout the plant should not be used unless the entire stand is to be killed.

WILLOWS

BEBB WILLOW, *Salix bebbiana* Sarg. Also called Beak, Beaked, and Long-Beaked Willow.

PUSSY WILLOW, *Salix discolor* Muhl. Also called Glaucous Willow and Silvery Pussy Willow.

By James W. Rawson

*West Virginia Department of Natural Resources
Elkins*

RANGE

Pussy willow is found throughout the Northeast, and Bebb willow occurs in all northeastern provinces and states except New Jersey, West Virginia, and Kentucky (Fernald 1950, Gleason 1963b, Rehder 1940, Strausbaugh and Core 1953:II, U. S. Forest Service 1948). Many willow species that attain shrub size are found within the Northeast. Much of what follows may be applicable to species other than those mentioned above. In choosing a willow for shrub plantings, a species that exhibits the characteristics desired and grows well under local conditions similar to those of the planting site should be utilized.

HABITAT

Both willow species discussed here will withstand most climatic extremes encountered in the Northeast. Best willow growth is attained in rich, deep, moist, alluvial bottomlands. Moderate growth usually occurs in any sufficiently moist soil type. Willows will tolerate moderately alkaline soils, but do poorly in extremely acid or alkaline conditions (Lamb

1915). The general pH range for willows is 5.5 to 7.5 (Altman and Dittmer 1962, Spector 1956). Bebb willow is usually found in moist, sandy or gravelly, rich soils; pussy willow commonly occurs in moist meadows and along lakes and streams (U. S. Forest Service 1948). Both species possess one to a few stems and average 6 to 16 feet in height (Gleason 1963b).

LIFE HISTORY

Male and female flowers are catkins, an inch or more in length and born on separate trees. They appear before or with the leaves (Altman and Dittmer 1962, Berry 1917, Lamb 1915, Spector 1956, U. S. Forest Service 1948). Apparently bees are the chief pollinating agent. The fruit is a capsule containing many minute hairy seeds, which usually ripen in early summer but in some species during fall. The seeds are disseminated chiefly by wind and water. Pussy willow flowers in March and April, Bebb willow in May and June. The fruit of both species ripens soon after flowering (Berry 1917, U. S. Forest Service 1948). The optimum seed-bearing ages of

Bebb and pussy willow are 10 to 30 years and 8 to 25 years respectively (*U.S. Forest Service 1948*).

The seeds are small and light and number approximately 2 to 3 million per pound. The cottony mass attached to each seed facilitates wind dispersal shortly after the fruit ripens (*Berry 1917, Lamb 1915, Massey and Ball 1944, U. S. Forest Service 1948*). Seed dispersal of Bebb and pussy willow occurs in May and June and April and May, respectively (*U. S. Forest Service 1948*).

Willows also reproduce well by suckers, sprouts, and root shoots (*Bailey 1950, Edminster and May 1951, Lamb 1915, Van Dersal 1938*).

Some willows are considered pioneer species. They are all very intolerant and do not compete well where shading occurs. Willows grow rapidly in good soils and full sunlight; under such conditions, they often dominate other species (*Lamb 1915, Spector 1956, Van Dersal 1938*). Willows are generally short-lived (*Spector 1956*).

USE BY WILDLIFE

Willows are a major browse of moose throughout most of their range and a prime source of food for deer. Willow shoots and buds are eaten by many rodents (including muskrat and beaver) as well as rabbits and hares (*Martin et al 1951, Massey and Ball 1944; Shomon 1957; Van Dersal 1938*). Willow buds and twigs are utilized to varying degrees by several members of the grouse family (*Allison 1966, Martin et al 1951, Van Dersal 1938*). Certain ducks and water birds feed on willow catkins and leaves. Willow sap is reported to be utilized extensively by sapsuckers (*Massey and Ball 1944*).

Because of their abundance and thicket-forming habits, willows provide cover and protection for many wild birds and mammals (*Shomon 1957*). Streamside willows provide valuable brood cover for several species of wild ducks.

Bees utilize willow nectar to produce high-grade honey (*Lamb 1915, Massey and Ball 1944, Shomon 1957, Strausbaugh and Core 1953:II*).

PROPAGATION

Willow seeds are viable for only a few days; therefore commercial sources are not available. However, cuttings may be obtained readily from standing or newly felled willows (*Bailey 1950, Edminster and May 1951, Lamb 1915, Laurie and Chadwick 1931, U. S. Forest Service 1948*).

Willow seeds should be collected immediately after the fruit ripens. This may be ascertained when the capsule changes from green to yellowish-green. Close surveillance of the fruits is necessary. The seeds may be collected directly or—if they are in the vicinity of water—from drifts at the water's edge. The seed should be sown immediately after collection, but may be stored for as long as 4 to 6 weeks. For short storage periods (up to 10 days), the seed may be placed in closed containers at room temperature where relative humidity of the air surrounding the containers remains above 50 percent (*U. S. Forest Service 1948*).

After broadcast of seeds, the well-prepared seedbed should be cultipacked. Germination usually occurs in 12 to 24 hours. High moisture levels must be maintained in the seedbeds at least until the seedlings are well established. This may be accomplished with shading and burlap coverings. Seedlings should be transplanted at 3 to 4 weeks of age to give them more room to grow. In most cases, 1-year old seedlings are large enough for field planting (*U. S. Forest Service 1948*).

Nursery stock should be sprayed to control leaf rusts (*Melampsora* spp.) if they are known to be present. Fungus scab and black canker may harm or kill leaves and shoots of susceptible willow species (*U. S. Forest Service 1948*).

Most authorities agree that cuttings should be procured from young vigorous stems, but one source maintains that cuttings should be taken from those shrubs exhibiting normal growth because they contain greater quantities of stored materials (*Laurie and Chadwick 1931*). Two-year old sprouts are frequently used (*Lamb 1915*). Cuttings 8 to 10 inches long should be planted 6 to 8 inches deep with about two buds remaining above the level of the soil (*Edminster and May 1915*). In gen-

eral, the smaller the cutting (if protected from mechanical injury), the less chance of disease (Lamb 1915). Cuttings should be made with a sharp knife or pruning shears before initiation of spring growth. Cuttings in February are recommended for the Northeast (Edminster and May 1951, Lamb 1915). Both species of willow cuttings are easily rooted. Treatments with growth regulators are considered unnecessary, but rooting of pussy willow has been hastened by using indolebutyric acid (IBA) (Doran 1957). If cuttings are to be stored, they should be buried upright in moist sand and kept in a cool dark place (Lamb 1915). In general, planting should be done in early spring. In some cases (where the cuttings were not exposed to direct sunlight) satisfactory growth has been observed on areas planted as late as July (Edminster and May 1951, Lamb 1915).

When planting, a dibble should be used to avoid stripping the bark. Care should be exercised when closing the dibble hole to eliminate air spaces (Edminster and May 1951).

MANAGEMENT

Willows may be planted in wet areas where wildlife food or cover is desired or to protect soil from erosion by running water (Edminster and May 1951, Lamb 1915, Shomon 1957).

When willow plantings are to be established for erosion control, the following should be considered:

1. Perpendicular banks must be altered to produce a sloping bank before planting can be effective.
2. Planting should begin at the water and proceed away from it.
3. Mechanical aids are often necessary to create conditions conducive to effective planting.
4. Generally, any part of a live willow will grow if placed in moist soil (Lamb 1915).

If rapid establishment of willow is desired

for either dense cover or erosion retardation where conditions are not severe, willow stakes 2 or more inches in diameter may be driven into the bank at close intervals, during periods of low water. The spaces between the stakes may then be filled with willow brush of all sizes. Partially bury as much brush as possible. Forked stakes may be driven into the brush to hold it more securely (Lamb 1915).

In cases of severe erosion, willow poles 18 to 20 feet in length should be cut and laid on the bank at 2- to 3-foot intervals with their butts facing the stream. Woven-wire fencing is then fastened to the poles, leaving 2 or 3 feet of the poles projecting below the bottom of the wire if the bank is soft mud, and less if the bank is composed of firmer material. Wire sections about 100 feet long can be handled most effectively. After the wire has been secured to the poles, the poles are pushed over the bank together to allow the butts of the poles to sink into the mud at the water's edge. Eroding soil will lodge in the wire and facilitate natural burying of the poles. The ends of the wire should be secured by cables running up the bank and held by a deadman (Lamb 1915).

Purple-osier willow (*Salix purpurea*) is recommended for streambank plantings in the Northeast because of its resilience, ability to layer new plants, and tendency to recover quickly from mechanical damage (Edminster and May 1951). Species found to be ill suited for such plantings were coyote willow (*S. exigua*), streakwood willow (*S. holosericea*), Hooker willow (*S. hookeriana*), and *S. myrsinifolia* (Edminster and May 1951).

Frequent replacement of plantings may be necessary on streambanks where washouts occur (Edminster and May 1951). Where cuttings or nursery stock are used, an early cleaning of other vegetation may be necessary (Lamb 1915).

Troublesome willows may be controlled with foliage or basal sprays of 2,4-D or a combination of 2,4-D and 2,4-DP (Amchem Products 1969, Spector 1956, U. S. Department of Agriculture 1961b).

COMMON WINTERBERRY

Ilex verticillata (L.) A. Gray

Also called Black Alder, Canada Holly, Coonberry, Deciduous Holly, Michigan Holly, Swamp Holly, Virginia Winterberry, and Winterberry.

By Arthur W. Holweg

*New York Department of Environmental Conservation
Albany*

RANGE

Common winterberry occurs throughout the Northeast and beyond; from Newfoundland to Ontario and northern Minnesota, and south to southeastern Missouri, Tennessee, southeastern Louisiana, Georgia, and northern Florida.

HABITAT

Winterberry is most commonly found on wet soils, but grows on upland soils that are moderately cool and moist. On drier soils, height growth is reduced (*Zucker 1966*). Like other hollies, winterberry prefers soils that are fairly high in organic content and slightly acid (*USDA 1967*). A pH of 5.5 is about average under natural conditions (*Curtis 1959*).

Growth rate, form, and fruit production are best in plants growing in the open or in light shade, and free from aggressive competition. However, winterberry has been recommended for landscape planting in moist, shady locations (*Kammerer 1934*).

In New York, winterberry grows at elevations up to 1,800 feet in the Adirondacks and at 1,400 feet on the Tug Hill Plateau (*Hotch-*

kiss 1932). But farther north it typically grows at lower elevations. In Canada and northern New England, winterberry usually occurs in swamps and bogs, along shores of ponds, and thickets (*Hodgdon and Steele 1958*), and is common on the Coastal Plain.

In the north, the dominant trees associated with winterberry include northern white-cedar, balsam fir, eastern hemlock, yellow birch, black ash, tamarack, red maple, silver maple, and American elm. Shrubs commonly found growing with winterberry are hobblebush, alders, blackberries and raspberries, red-osier dogwood, swamp red currant, swamp black currant, American hazelnut, red-berried elder, highbush cranberry, bunchberry, yew, and American fly honeysuckle (*Curtis 1959, Hodgdon and Steele 1958*). Southward, beech, basswood, sorgum, swamp white oak, black oak, and pines take the places of the more northerly species. Swamp azalea, spicebush, pussy willow, buttonbush, virginsbower, sweet pepperbush, inkberry, American bittersweet, and highbush blueberry replace the more northern shrubs (*Grimm 1952, Wyman 1966*). The communities are quite stable.

LIFE HISTORY

Individual plants bear either male or female flowers, and the sex of a plant ordinarily cannot be determined when the plant lacks flowers or fruit. The flowering period varies from April to July over the entire range and is later in the colder locations. Flowers are greenish or yellowish-white and inconspicuous, but attractive to bees. Male blossoms are borne in clusters, each cluster attached to the twig by a common stalk. The female blossoms occur singly. Flowers are borne on the basal part of the current-year's twig growth (*Neal and Pease 1954*). Because of relatively late blooming, frost damage to flowers is infrequent, but may occur in frost-pocket locations.

The fruits are berry-like, about ¼-inch in diameter, and bright red when ripe in September or October. However, summer drought may cause the developing fruits to atrophy. The ripe fruits show best after leaf fall, and often persist on the plants until January or later. Dissemination of the fruit is by birds and by mammals such as raccoons and squirrels.

The fruits of some holly species have been reported as poisonous to man (*Hottes 1949*), but it is doubtful that any of the North American species is toxic (*Kingsbury 1969*).

Vigorous plants that have attained good size may bear several thousand fruits. Age of plants at first fruiting has been reported as 3 years where plants were growing in full sunlight (*Spinner and Ostrom 1945*), and 5 years on less favorable sites. Average height at maturity is about 9 feet, but plants may range from 3 to 20 feet, and rarely to 25 feet.

Winterberry reproduces by means of seed, suckers, and layers. Seeding is the most common method of spread, due to the attractiveness of the fruits to birds and mammals. Undigested nutlets are passed through animals and deposited in their droppings.

Winterberry does not compete well with aggressive faster growing associates. However, once established, its ability to send up numerous root suckers enables winterberry to maintain itself in a suitable situation. Survival is also favored by the fact that winterberry stems are not preferred foods of deer, cottontail rabbits, or snowshoe hares. Winterberry

tolerates partial shade and often persists in the forest understory.

USE BY WILDLIFE

Winterberry provides food—fruit, browse, or both—for many species of wildlife. The principal browsers are deer, moose, cottontail and snowshoe hare. The fruit is eaten by various small mammals and more than 48 species of birds. Reported consumers include raccoon, white-footed mouse, red squirrel, ring-necked pheasant, ruffed grouse, sharptailed grouse, bobwhite, black duck, wood duck, robin, pine grosbeak, brown thrasher, waxwing, catbird, flicker, thrushes, bluebird, starling, and many other small birds (*personal communications from J. W. Alger, G. T. Chase, A. J. Fordham, N. Hotchkiss, H. L. Mendall, A. E. Patton, A. Sonborn, Sally Spofford, D. Q. Thompson, and J. E. Tanck*).

Because winterberry seldom forms extensive stands, the cover it provides is usually inferior to that provided by plants such as alders, gray dogwood, sumacs, hawthorns, or greenbriers. But where the latter plants grow in association with winterberry, it may enhance the total cover value, particularly for those small birds that nest on or within 15 to 20 feet above the ground. Winterberry often forms part of such cover in gullies, ditches, and other wet places.

Because winterberry ranks low in browse preference, it can persist in an understory unless serious overbrowsing occurs.

PROPAGATION

Planting stock and seed can be purchased (*NE Reg. Tech. Serv. Ctr. 1971*), and winterberry can be propagated from either cuttings or seed. Fruits number about 2,000 per pound (*Van Dersal 1938*) and each ordinarily contains 4 to 6 seeds. The yield is 11 to 20 pounds of cleaned seed per 100 pounds of fruit. Numbers of cleaned seed per pound ranged from 40,000 to 129,000 and averaged about 92,000 (*U. S. Forest Service 1948*).

The Arnold Arboretum recommends that seed should be gathered in mid-October at the latitude of Boston. Seed should be cleaned and can be either sown or stratified while

fresh, or dried for storage. Fall-planted seed normally does not germinate until the second spring or later (*Kains 1945*). But stratification has produced satisfactory germination, 52 to 73 percent, the first spring after ripening. Seeds were stratified in moist sand at 68°F (night) and 86°F (days) for 60 days, then at 41°F for 60 days, followed by 60 days in sand flats. Seeds stored dry over winter and planted in the spring may germinate in the following spring (*U. S. Forest Service 1948*). Seeds should be stored dry, in sealed containers, and at low refrigerator temperatures (*Heit 1967e*). Storage life of the seeds apparently is limited to about 1 year.

Seedlings or rooted cuttings can be purchased, but the sex of such plants is usually unknown. One should buy several plants to be fairly sure of having both males and females; even this is not certain because all the cuttings may have come from one plant. Balled and burlapped plants can be obtained, and these may have the sex specified. A visit to the nursery during the blooming or fruiting periods enables one to choose plants of the desired sex.

There are several methods of vegetative propagation. The plants commonly send up suckers that can be dug each year and used as sources for softwood or hardwood cuttings that have the same sex and desirable characteristics as the parent plant. If desired, clusters of winterberry plants can be dug and divided with a spade or ax. The several plants thus obtained can be replanted. If this were anticipated or stock plants of a particular selection were desired, mound layering should work well—covering the base of each plant with a mound of soil and then cutting back the top severely. Formation of new shoots will be stimulated, and the following fall or spring the plants can be lifted and divided and the segments replanted.

One wholesale nursery propagates a named selection from softwood cuttings taken early in the growing season, while the cuttings are still very soft. The cuttings are rooted under mist. But according to *Doran (1957)*, summer cuttings and hardwood cuttings taken until late winter will be satisfactory if kept moist and given a growth hormone treatment to aid

rooting. Winterberry cuttings rooted better in peat moss than in sand, and both summer and hardwood cuttings rooted in 18 days at 80°F.

It is probably easiest to root winterberry from cuttings with foliage. Cuttings 3 to 6 inches long should be made from twigs of the current season, with foliage that has just matured. One-third of each cutting should be inserted in the rooting medium, and the propagating area should be covered with glass or plastic to insure high humidity without misting. New growth matures from late spring to midsummer, and maturity is indicated by foliage change from light green to medium or dark green.

No direct-seeding has been done on a large scale and some direct-seedings at Newcomb, New York, were not successful (*Webb and Patric 1956*). Delayed germination makes evaluation of such efforts difficult. The Soil Conservation Service, after planting trials from New York to Maryland during the late 1930s and 1940, did not endorse winterberry for conservation plantings (*Edminster and May 1951*). Included in their nine criteria were two that could serve to restrict use of the species: site adaptability and availability. Many planting sites lack the moist, acid soils with high humus content that winterberry prefers.

Some people who have moved winterberry from the wild to their own properties report excellent establishment. Plants at least 2 years old are recommended, and older plants would be preferable. Late fall, especially in dry seasons, is a good time to transplant these shrubs from the wild because the typically swampy habitat is usually driest then. Also male and female plants usually can be distinguished.

MANAGEMENT

Female winterberry plants must have a pollen source close by if they are to bear fruit. The pollen need not be from a male winterberry, but if a male of another holly species is present it must flower at the same time as the female winterberry (*Fogg 1960*). The male winterberry or other holly should be within 40 feet of the female for good pollination. Many people who grow hollies as ornamentals set plants of both sexes in the same hole to insure

pollination. The pollen from one male should be adequate to pollinate several female plants (*Link 1945*). To realize the wildlife potential of this species, it is advantageous to have a preponderance of female plants in any planting.

Winterberry in the vicinity of rural or suburban residences will have tremendous eye appeal in the fall and early winter. Excellent landscape effects are obtained by using winterberry with broadleaved evergreens and low growing conifers (*Zucker 1966*). The increasing availability of selected forms enables tailoring the plantings to the site. Incorporating peat in soils, maintaining a good mulch for the first year, and planting to take advantage of natural moisture should help the plants get a thrifty start.

Because winterberry grows upright and tends to be bare in its lower framework, it is not practical to try to get much leafing close to the ground. Better form can be achieved by pinching basal shoots, thus inducing lower branching, and plants can be encouraged to

fruit better by cutting out some of the oldest stems every few years. Such measures could be practiced where the plants are showpieces. On a less intensive basis, a hedgerow of winterberry could be cleaned of competing vegetation periodically. If such a planting were used on a wetland area, the placement could be made to insure that the routine mowing would help release the winterberry from competition with other woody growth.

Winterberry ordinarily does not require protection from insects or diseases.

Nurseries are selecting plants that have good fruiting qualities and compact form or other desirable growth habits. Breeders are trying to develop small plants with superior foliage (*Dengler 1957*). As these superior selections become better known, the fine ornamental qualities of winterberry will increase its popularity considerably. The disadvantage of having separate male and female plants will be partly overcome by the increasing popularity of hollies and through grafting or hormone spraying.

WITCH-HAZEL

Hamamelis virginiana L.

Also called Café DuDiable (Quebec), Common Witch-Hazel, Hamamelis, Long Boughs, Pistachio, Snapping Alder, Snapping Hazel, Snapping Hazel-Nut, Southern Witch-Hazel, Spotted Alder, Striped Alder, Tobacco Wood, White Hazel, Winterbloom, Witch-Hazel, and Wood Tobacco.

By Gene W. Wood

Pennsylvania State University
University Park

RANGE

Witch-hazel is a wide-ranging species found across southeastern Canada and most of the eastern United States except southern Florida and the Gulf Coast. The species discussed here includes the one formerly called *H. macrophylla* Pursh., but is distinct from vernal witch-hazel (*H. vernalis* Sarg.), which occurs in the Ozark region (Little 1953).

HABITAT

This species is found over a wide variety of climatic conditions. It ranges from areas with winter temperature lows of -40°F to southern areas where summer temperatures commonly exceed 100°F . Low temperatures probably have little effect on growth of this shrub because winter-kill is rarely noted; and I found no mention of sun-scald.

Precipitation requirements are between 35 and 50 inches of annual rainfall. The plant is hardy and suffers little even in drought years. Growing-season lengths vary from 2 to 10 months over the range of the species.

Witch-hazel is found on a wide variety of

sites. It may be found on high, dry mountain ridges as well as along small valley streams and lake edges. Soils may range from stony or loamy sands to silt loams. It is not usually found on organic soils, but is found on soils of both low and relatively high organic matter content. Individuals are particularly conspicuous on talus slopes, where few other plants are able to sustain themselves. It readily acclimates to droughty soils with low nutrient availability, but is also capable of growing well on better sites when given the opportunity. Witch-hazel is rather insensitive to soil reaction, but grows best at about pH 6.0 to 7.0 (Hosley 1938). Witch-hazel also withstands shaded, air-polluted, city conditions (Kammerer 1934).

As the broad geographic range and wide variety of sites indicate, this shrub is found with numerous associates. On the talus slope sites it is commonly found with sweet birch, paper birch, and chestnut oak. On sandy lowlands and upland plateaus it may be found beneath a canopy of white oak, black oak, scarlet oak, and red maple. On the more poorly drained areas witch-hazel may be found with sycamore

and American elm, and occasionally alongside black walnut on moderately drained soils. In the bottomlands, the shrub will be found with swamp white oak and shagbark hickory.

Witch-hazel is not a pioneer species, although it may sprout vigorously from stumps on cutover areas. Seedlings will also appear on these newly opened sites. The shrub is almost always found as part of the understory and may often make up a significant part of this layer, especially on droughty sites. The majority of stems are from sprout origin and may form relatively distinct communities in the understory due to their growth habit of dense clumps with interlacing tops.

When the tree canopy is removed and the witch-hazel is left undisturbed, it will dominate the site for a short time only. Stump sprouts and seedlings of tree species will reclaim dominance through their more vigorous height growth.

LIFE HISTORY

Witch-hazel is peculiar in that it flowers in the fall, from September to November. The flowers are bright yellow and quite conspicuous after leaf-fall. They may often be seen covered with snow.

The fruit that began development the previous year is usually ripe while the flowers of the current year are blooming. The ellipsoidal-shaped fruits are two-beaked at the apex and are borne in pairs at the point of the original flower cluster. They are pale green, turning to brownish yellow on ripening. These woody capsules contain two dark chestnut-brown to black shiny seeds; each about $\frac{1}{8}$ x $\frac{3}{8}$ inch (*Hosely 1938*). Ripened capsules are usually available from 6 August to December (*Van Dersal 1938*).

When the capsule is completely ripe, the seeds are ejected—with a distinct snapping sound. They may travel several feet. Seed production is variable, abundant in some years and almost nonexistent in others. Production seems to be higher in wet years than in dry years.

Seed production will be greater on stems that are growing either in the open or along forest borders. Plants under tree canopies—though they flower lavishly and appear to be

as healthy as those in more open areas—rarely produce comparable amounts of seed. Production varies from one individual to another on the same site.

Seed may be collected just before full ripening of the capsule. Ejection of the seed will occur while the fruits are in warm dry storage.

Witch-hazel may be regenerated from seed or stump sprouts, or by suckering to a limited extent. Seedling reproduction is not common under closed canopies, but does occur on recently opened sites. The major source of reproduction is from clumps of sprouts that originate from one single stem. After 8 to 10 years, the parent stem is not particularly obvious. Sprouting may occur from cut stumps or stumps of shrubs killed by fire.

Among young, well-spaced plants growing on fertile nursery soils in Massachusetts, the growth period was 18 weeks, 24 April to 28 August. Maximum growth occurred in June, and 90 percent of total growth occurred from 15 May to 7 August (*Kozlowski and Ward 1957*).

Growth rates of seedlings may range from a few inches per year on dry sites to several feet on moist areas. Height growth is greatest in the first few years, then slows down, the stem increasing in diameter and branching out. The leader becomes inconspicuous at this point and the crown becomes rounded and begins to bend over toward the ground, giving the appearance that the crown is too heavy to be supported by the trunk. At this stage seed production will be at its peak and shoot growth at its minimum. New shoots on the branches will rarely be more than 1 inch long.

Stump sprouts grow more vigorously than the other two forms of reproduction. Sprouts I have observed grew as much as 4 feet in a single season, even on dry sites. The sprouts show a great deal of variation in ability to make this type of growth. Stems of the same age from the same clone may vary from 6 inches to 4 feet in height. Total height is rather hard to measure, because the larger individuals have no distinct leader. The tops of the crowns are commonly 10 to 15 feet from the ground, but a total height of 25 feet and a spread of 15 to 20 feet may be reached by this species (*Bailey 1935, Sargent 1949, Spector 1956*).

Witch-hazel has been considered relatively free from insect and disease attacks (*Hosley 1938, Van Dersal 1938*), but is commonly plagued by aphids, which cause two types of galls. The cone-gall, which appears on the leaves in mid-summer, is the more common. These galls may form dense clusters, and the aphids from them may completely defoliate the shrubs. The gall is conical in shape and scarlet red in color. A less common gall is the spiny witch-hazel gall, which occurs on the flower bud and prevents fruiting. For both of these gall-diseases, birches are alternate hosts (*Comstock 1950*). Presumably, witch-hazel growing beyond the range of birches will not be infected.

USE BY WILDLIFE

The leaves and shoots of witch-hazel are browsed by deer in varying degrees, depending upon the range condition. In areas where there is a wide choice of foods in large quantities, witch-hazel may rarely be eaten, though in unproductive areas it may be a staple in the winter diet. Witch-hazel was considered generally of low value to wildlife although it composed 5 to 10 percent of the diet of white-tailed deer in New York (*Martin et al 1951*). In the mixed-oak forests of central Pennsylvania, the shrub has a great deal of value since it is able to reproduce and maintain itself where other species cannot.

Chemical analysis of the shoots and leaves indicate that the concentrations of crude protein, calcium, and phosphorus in the leaves are about 10 percent, 0.81 percent, and 0.11 percent, respectively. Shoots contain about 6 percent crude protein, 0.56 percent calcium and 10.4 percent phosphorus (*Wood and Lindzey 1967*).

The bark of witch-hazel is occasionally used by beaver, squirrels, and rabbits. Browsing and bark-stripping by cottontails severely injured witch-hazel stands in Massachusetts (*Sweetman 1944*). Seeds are utilized by turkey, bobwhite, pheasant, and squirrels (*Hosley 1938; Martin et al 1951*). Buds and flowers as well as seeds are eaten by ruffed grouse (*Hosley 1938*).

Thickets of witch-hazel provide cover for wild animals. The thickets form windbreaks

and escape cover for small birds and mammals.

PROPAGATION

Witch-hazel can be propagated from cuttings or seed. Seed is available commercially after good seed years and 1970 prices for cleaned seed were about \$9 to \$10 per pound; a pound contains 8,700 to 10,900 seeds (*Swingle 1939, U. S. Forest Service 1948*). Cleaned seed is ordinarily pretreated and sown in spring, but fresh seeds can be sown in late summer.

Ripe untreated seeds ordinarily take 2 years to germinate (*Van Dersal 1938*). They exhibit double dormancy, which can be broken in two ways. If late summer planting is desired, the seeds should be collected before they ripen completely and sown by early September (*Heit 1967e*). In Iowa, seeds that were immature yet past the milk stage were collected in late August and planted immediately. They germinated 90 percent the following spring (*Titus 1940*).

If immediate planting is not desired, the seeds should be collected later, when the fruits are dull orange-brown or blackened and just before the capsules split to eject the seeds. The fruits should be spread out to dry, and the capsules can be removed by screening. Cleaned dried seeds can be stored in sealed containers at 41°F for 1 year without loss of viability (*U. S. Forest Service 1948*).

To prepare for spring sowing, seeds can be stratified over winter in a sand/peat mixture at 41°F or can be hot-water soaked, then warm-stratified for 60 days at 68 to 86°F and then cold-stratified for 90 days or longer at 41°F (*Chadwick 1935, Swingle 1939, U. S. Forest Service 1948*). The latter treatment may be better, but more research on dormancy-breaking treatments is needed. In a test of pretreated seed, germinative capacity was only 17 percent, but potential germination was 81 percent (*U. S. Forest Service 1948*). Another test yielded only 324 usable plants per pound of seed (*Swingle 1939*).

In the nursery, late-summer sowing should be done shortly after the seeds are gathered. The beds should be mulched with burlap, straw, or leaves and the mulch removed at ger-

mination time in the spring. Spring sowing of stratified seed is done as early as soil conditions permit. Seed may be broadcast or planted in drills (preferred), with 8- to 12-inch spacing. Surface soil should be kept moist until germination is complete. If untreated seed is used, the beds should be mulched and kept intact until the following spring (*U. S. Forest Service 1948*).

Witch-hazel should be planted on rather moist peaty or sandy soils (*U. S. Forest Service 1948*). The best natural seedbeds are rich forest soils in partial shade. However, it appears that witch-hazel will germinate and grow wherever there is enough decomposed litter to hold moisture and provide a rooting medium.

Field sowing was not discussed in the literature, but it appears that the best results would be obtained from spring sowing of stratified seed. Late-summer sowing could be done, but at a high risk of depredation from birds and small mammals. In either case the sowing should be done on organic-matter accumulations, preferably in contact with humus or peat.

Propagation from cuttings has not been considered easy because of considerable mortality of rooted cuttings during the first winter (*Doran 1957*). But in one test, cuttings rooted 92 percent in sand in 76 days without treatment (*Chadwick 1944*). With species closely related to *H. virginiana*, fair to good results were obtained from cuttings treated with IBA (50 mg/l) for 20 to 22 hours. High relative humidity, 85 to 90 percent, gave twice as much rooting as 65-70 percent humidity (*Doran 1957*).

MANAGEMENT

The primary objective in managing for witch-hazel is to provide a food source on normally nonproductive areas. Witch-hazel can take advantage of these sites and provide food and cover where many other shrubs would not be able to sustain themselves. The seed will be utilized by song and game birds. The shoots and foliage will be taken by deer, rabbits, and beaver.

The shrub is often planted as an ornamental, although foreign species or horticultural varieties are used more often than the native species. The showy fall flowers and heavy summer foliage make witch-hazel desirable for roadside plantings and picnic areas.

Witch-hazel may be grown in full shade or in full sunlight and on dry as well as moist sites. The very best production will be under a thin overstory canopy on moist sites. Seed production will be high along forest borders.

Control of witch-hazel with the pelleted herbicides fenuron, dicamba, and picloram is effective (*Eichert 1965*). Stumps may be treated with herbicides to control stump sprouting. Witch-hazel is very susceptible to light fire. Top-kill is easily achieved through very light controlled burning where only the recent litter is destroyed.

MISCELLANY

The twigs, leaves, and bark are used to prepare witch-hazel extract for shaving lotions and sprain or bruise ointments. Fresh leaves are astringent because of high concentrations of tannin (*Krochmal et al 1969*).

CANADA YEW

Taxus canadensis Marsh.

Also called American Yew, Buis de Sapin, and Ground Hemlock.

By Arthur M. Martell

Acadia University
Wolfville, Nova Scotia

RANGE

This species occurs in all the provinces from Newfoundland to Manitoba, and extends southward to western Virginia, eastern Kentucky, and northeastern Iowa; the southward range in the Northeastern States is mostly in the uplands (Fernald 1950, Gleason 1963a). However, Canada yew has been practically extirpated where deer populations are or have been exceptionally high—notably in New York, Pennsylvania, Michigan, and Wisconsin (Leopold et al 1947).

HABITAT

Canada yew prefers a cool moist climate. It grows best in shady situations and on well-drained silt loam (Bailey 1933), and is best adapted to soils with a pH of 5.0 to 7.5 (Altman and Dittmer 1962, Spector 1956). Being highly shade-tolerant (Spector 1956), it is found mostly in shady woods and thickets, in bogs, and on cool banks (Bailey 1933, Fernald 1950, Gleason 1963a).

Canada yew is (or was, before eradication by deer) a common shrub of the hemlock-white pine - northern hardwood region, which

dominates the northern half of the Northeast, and of the mixed mesophytic forests of the Allegheny Mountains. It is also found in bog remnants in the beech-maple forest region west of the Alleghenies and is scattered in the oak-chestnut forest region to the east, but not in eastern Maryland and New Jersey (Braun 1950).

Throughout its range, Canada yew occurs primarily as a characteristic shrub in mature-successional-stage or climax forests.

LIFE HISTORY

Canada yew flowers are single-sexed, but both sexes are usually borne on the same plant (Bailey 1935), unlike most of the exotic yew species. The male flowers are solitary or in small spikes from the leaf-axils, and the female flowers are on short axillary shoots. Flowering occurs in April to May, and the fruit ripens during July to September (U. S. Forest Service 1948). The fruit at maturity is one bony-coated seed, more or less surrounded by a scarlet, fleshy, cuplike disk, about 5 mm long and open at the top (Fernald 1950, Gleason 1963a).

No information about the youngest or oldest seed-bearing age, seed production per plant, or the dissemination of seeds was found. Some seed is produced almost every year (*U. S. Forest Service 1948*), but fruit crops are usually light and irregular (*Van Dersal 1938*).

Canada yew is more cold-hardy than any of the exotic yews (*Rehder 1940*).

USES

Canada yew is browsed year-round by moose (*Peterson 1955*), and is a choice winter food of deer (*Taylor 1961*). However, yew does not withstand much browsing; for example, yews planted for wildlife purposes in New York were practically destroyed by deer (*Smith 1964*). This preference by deer and other wildlife is remarkable because the seeds and wilted foliage of Canada yew may fatally poison livestock. The needles and seeds contain toxins that act as a heart depressant (*Bump et al 1947*).

Canada yew was not harmed by rabbit browsing in a Connecticut study area where many other shrubs were severely damaged (*Sweetman 1944*).

The fruits of Canada yew are eaten by ruffed grouse (*Bump et al 1947*), pheasants, and a few species of nongame birds (*Hosley 1938*). In Massachusetts, yews (species not stated) attracted starlings, cedar waxwings, robins, bluejays, and squirrels in mid-October when the fruit ripened (*Fordham 1967*).

Canada yew is used much less in landscaping than exotic yews, particularly English and Japanese yew, because the native species is less adaptable and produces less fruit (*Hosley 1938*). However, Canada yew was rated excellent for roadside use in "cool" locations (*Wisconsin Conservation Department 1967*).

PROPAGATION

Seed or planting stock probably is not available commercially (*Northeast Reg. Tech. Serv. Cent. 1971*). Seeds may be collected in the fall, but only fully mature, plump, scarlet fruits should be harvested. They produce the most successful seedlings. The seeds can be extracted by mixing the fruits with sand and screening out the seeds or by macerating the

fruit in water. If the fruit-water mixture is allowed to ferment a few days, the seeds are more easily separated (*Heit 1969*). Yields in four samples averaged about 21,000 cleaned seed per pound and ranged from 15,000 to 32,000 (*Swingle 1939, U. S. Forest Service 1948*). Cleaned seeds may be stored for a few years under sealed refrigeration at 32 to 40°F (*Heit 1967d*).

Little specific data on germination in Canada yew is available, but the following information for other yew species may apply. Yew seeds are not hard-coated and do not require scarification. They are extremely dormant and require a warm treatment followed by a cold treatment. The shortest effective treatment consisted of a 4-month warm period (60 to 65°F) followed by a 3-month cold period (34 to 40°F); however, a 7-month warm period followed by a 2-to-4-month cold period was more effective (*Heit 1969*).

Seed stored over winter and sown in the spring produce good seedling stands early in the following spring. Beds must be mulched heavily with pine needles, wood shavings, or straw to maintain moisture during the summer. Shading may also help prevent excessive temperatures. Sowings should be made no later than July for successful stands the following spring. Fall sowings do not germinate until the spring of the second year and may produce only a partial stand of seedlings (*Heit 1969*).

Canada yew may also be propagated from hardwood cuttings (*Bailey 1933*). Those with either 1-, 2-, or 3-year-old wood at the base rooted about equally well, but cuttings that included 3-year-old wood produced large plants more quickly. Treatment with IBA (50 mg/l for 18 hours) may increase the rooting. Sand, sand-peat mixtures, and sandy soil have been used as rooting media; and bottom heat, about 70°F, has improved rooting in some yew species (*Doran 1957*).

In the field, Canada yew grows best in at least partial shade. It does well in open exposures provided the roots are thoroughly mulched and kept cool. However, the leaves are smaller and lighter green than when grown in shady areas. Also, a southern exposure and late winter sun or a cold north wind will

brown the foliage of exposed plants (*Bailey 1933*).

MANAGEMENT

Locally, Canada yew may have doubtful value in wildlife habitat management because of its susceptibility to damage from deer or moose browsing and its toxicity to livestock.

Perhaps the best reasons for considering yew would be those in which a wildlife purpose is coupled with landscape enhancement (*Wisconsin Conservation Department 1967*) or a desire to reestablish native species of shrubs. Need for control of yew is unlikely, and no recommendations for herbicidal treatment were found.

LITERATURE CITED

- Aalders, L. E., and I. V. Hall.
1961. POLLEN INCOMPATIBILITY AND FRUIT SET IN LOWBUSH BLUEBERRIES. *Can. J. Genet. and Cytol.* 3:300-307.
- Adriance, G. W., and F. R. Brison.
1939. PROPAGATION OF HORTICULTURAL PLANTS. McGraw-Hill Co., New York. 314 p.
- Affeltranger, C.
1965. IS RED MULBERRY VANISHING? *W. Va. Univ. Arbor. Newsl.* 15:2 p.
- Aldous, Shaler E.
1952. DEER BROWSE CLIPPING STUDY IN THE LAKE STATES REGION. *J. Wildl. Manage.* 16:401-409.
- Allison, D.
1966. IMPROVING YOUR LAND FOR RUFFED GROUSE. N. H. Dep. Fish and Game. 18 p.
- Altman, P. L., and D. D. Dittmer (editors).
1962. GROWTH, INCLUDING REPRODUCTION AND MORPHOLOGICAL DEVELOPMENT. *Fed. Am. Soc. for Exp. Biol. Biol. Handb. Serv. Washington, D. C.* 608 p.
- Amchem Products, Inc.
1969. WEED AND BRUSH CONTROL (Datalog). Amchem Products, Inc., Ambler, Pa. 76 p.
- Ammann, G. A.
1957. THE PRAIRIE GROUSE OF MICHIGAN. *Mich. Dep. Conserv.* 200 p.
- Ammons, Nelle.
1950. SHRUBS OF WEST VIRGINIA. *W. Va. Univ. Bull. Serv.* 50:12-4. 127 p.
- Arend, J. L., and E. I. Roe.
1961. RELEASING CONIFERS IN THE LAKE STATES WITH CHEMICALS. *USDA Handb.* 185. 22 p.
- Auten, John T.
1945. RELATIVE INFLUENCE OF SASSAFRAS, BLACK LOCUST, AND PINES UPON OLD FIELD SOILS. *J. Forest.* 43:441-496.
- Bailey, James A.
1967. MINERAL CONTENT OF DEER BROWSE ON THE HUNTINGTON WILDLIFE FOREST. *N. Y. Fish and Game J.* 14:76-78.
- Bailey, L. H.
1916. THE STANDARD CYCLOPEDIA OF HORTICULTURE. MacMillan Co., New York. Vol. 5:2930-2948.
- Bailey, L. H.
1933. THE CULTIVATED CONIFERS IN NORTH AMERICA. MacMillan Co., New York. 404 p.
- Bailey, L. H.
1935. THE STANDARD CYCLOPEDIA OF HORTICULTURE. MacMillan Co., New York. Vol. 2:3639 p.
- Bailey, L. H.
1941-45. RUBUS IN NORTH AMERICA. *Gentes Herbarum* 5:1-932.
- Bailey, L. H.
1947. RUBUS IN NORTH AMERICA. *Gentes Herbarum* 7:181-349.
- Bailey, L. H.
1949. RUBUS IN NORTH AMERICA. *Gentes Herbarum* 7:481-526.
- Bailey, Liberty H.
1950. THE NURSERY MANUAL. MacMillan Co., New York. 456 p.
- Bailey, R. W., and K. T. Rinell.
1968. HISTORY AND MANAGEMENT OF THE WILD TURKEY IN WEST VIRGINIA. *W. Va. Dep. Nat. Resour. Div. Game and Fish Bull.* 6. 59 p.
- Bailey, V.
1927. BEAVER HABITS AND EXPERIMENTS IN BEAVER CULTURE. *USDA Tech. Bull.* 21. 39 p.
- Baird, J. C.
1966. SOME ECOLOGICAL ASPECTS OF THE WHITE-TAILED DEER ON ISLE AUHAUT, MAINE. M. S. thesis, Univ. of Maine, 114 p.
- Bakuzis, Egolfs V., and Henry L. Hansen.
1959. A PROVISIONAL ASSESSMENT OF SPECIES SYNECOLOGICAL REQUIREMENTS IN MINNESOTA FORESTS. *Minn. Forest. Notes* 84. 2 p.
- Ballinger, W. E.
1966. SOIL MANAGEMENT, NUTRITION, AND FERTILIZER. *In BLUEBERRY CULTURE.* Rutgers Univ. Press. New Brunswick, N. J. 378 p.
- Banasiak, C. F.
1961. DEER IN MAINE. *Maine Dep. Inland Fish. and Game, Game Div. Bull.* 6. 163 p.
- Barber, H. L.
1962. "BROWSE" STUDY SHOWS FOOD AVAILABILITY FOR HERDS. *Ky. Happy Hunting Ground* 18(5):4-6.
- Barkley, F. A.
1937. A MONOGRAPHIC STUDY OF *Rhus* AND ITS IMMEDIATE ALLIES IN NORTH AND CENTRAL AMERICA, INCLUDING THE WEST INDIES. *Mo. Bot. Gard. Annu.* 24(3):265-460.
- Barrett, J. W., C. E. Farnsworth, and W. Rutherford.
1962. LOGGING EFFECTS ON REGENERATION AND CERTAIN ASPECTS OF MICROCLIMATE IN NORTHERN HARDWOODS. *J. Forest.* 60:630-639.
- Barton, Lela V.
1939. EXPERIMENTS AT BOYCE THOMPSON INSTITUTE ON GERMINATION AND DORMANCY IN SEEDS. *Sci. Hort.* 7:186-193.
- Barton, Lela V.
1958. GERMINATION AND SEEDLING PRODUCTION OF SPECIES OF VIBURNUM. *Plant Propag. Soc.* 8:126-135.
- Basset, I. J., R. M. Holmes, and K. H. MacKay.
1961. PHENOLOGY OF SEVERAL PLANT SPECIES AT OTTAWA, ONTARIO, AND AN EXAMINATION OF THE INFLUENCE OF AIR TEMPERATURES. *Can. J. Plant Sci.* 41:643-652.
- Bazzaz, F. A.
1968. SUCCESSION ON ABANDONED FIELDS IN THE SHAWNEE HILLS, SOUTHERN ILLINOIS. *Ecology* 49:924-936.
- Beals, E. W., G. Cottam, and R. J. Vogl.
1960. INFLUENCE OF DEER ON VEGETATION OF THE APOSTLE ISLANDS, WISCONSIN. *J. Wildl. Manage.* 24:68-80.
- Beckwith, C. S., and S. Coville.
1931. BLUEBERRY CULTURE. *N. J. Agr. Exp. Sta. Circ.* 229. 28 p.
- Beecher, A. S., R. H. Gruenhagen, and J. M. Amos.
1964. THE FLOWERING DOGWOOD. *Va. Polytech. Inst. Circ.* 948. 7 p.
- Bennett, H. H.
1939. SEED PROPAGATION OF TREES, SHRUBS, AND FORBS FOR CONSERVATION PLANTING. *U.S. Soil Conserv. Serv. Tech. Publ.* 27. 7 p.
- Berry, E. W.
1906. LIVING AND FOSSIL SPECIES OF COMPTONIA. *Am. Natur.* 40:485-524.
- Berry, E. W.
1917. NOTES ON THE HISTORY OF THE WILLOWS AND POPLARS. *Plant World* 20:16-28.
- Billington, C.
1949. SHRUBS OF MICHIGAN. *Cranbrook Inst. Sci. Bull.* 20. 339 p.
- Birdsell, D. G., D. P. Watson, and B. H. Grigsby.
1958. TOXICITY AND EFFICIENCY OF SELECTED HERBICIDES ON REPRESENTATIVE ORNAMENTAL PLANTS. *Weed Sci.* 6(1):34-41.

- Black, J. D.
1954. BIOLOGICAL CONSERVATION. Blakiston Co., New York. 328 p.
- Blair, R. M., and E. A. Epps, Jr.
1969. SEASONAL DISTRIBUTION OF NUTRIENTS IN PLANTS OF SEVEN BROWSE SPECIES IN LOUISIANA. USDA Forest Serv. Res. Pap. SO-51. 35 p.
- Blair, R. M., and L. K. Halls.
1968. GROWTH AND FORAGE QUALITY OF FOUR SOUTHERN BROWSE SPECIES. SE. Assoc. Game and Fish Comms. Annu. Conf. Proc. 21:57-62.
- Blair, W. Frank.
1936. THE FLORIDA MARSH RABBIT. J. Mammal. 17:197-207.
- Blaisdell, J. P., and W. F. Mueggler.
1956. EFFECT OF 2,4-D ON FORBS AND SHRUBS ASSOCIATED WITH BIG SAGEBRUSH. J. Range Manage. 9:30-40.
- Bonner, F. T.
1971. CHEMICAL CONTENTS OF SOUTHERN HARDWOOD FRUITS AND SEEDS. USDA Forest Serv. Res. Note SO-136. 3 p.
- Bowers, C. G.
1960. RHODODENDRONS AND AZALEAS. MacMillan Co. New York. 525 p.
- Boyce, J. S.
1938. FOREST PATHOLOGY. McGraw-Hill Book Co., New York. 600 p.
- Boyd, I. L.
1943. AN ECOLOGICAL STUDY OF FOUR SPECIES OF SUMAC IN RELATION TO DEVELOPMENT AND GROWTH ON ERODED SOIL. Kans. Acad. Sci. Trans. 47:51-59.
- Brady, Homer A.
1969. HERBICIDE MIXTURES PROMISING FOR HARDWOOD CONTROL BY FOLIAR SPRAYING. S. Weed Conf. Proc.:245-250.
- Bramble, William C.
1952. REFORESTATION OF STRIP-MINED BITUMINOUS COAL LAND IN PENNSYLVANIA. J. Forest. 50:308-314.
- Bramble, W. C.
1968. DO HERBICIDES AFFECT GAME? Pa. Game News 39:26-30.
- Bramble, W. C., and R. H. Ashley.
1949. PROGRESS REPORT ON SPOIL BANK PLANTING. Pa. State Coll. Agr. Exp. Sta. Prog. Rep. 24. 6 p.
- Bramble, W. C., and R. H. Ashley.
1955. NATURAL REVEGETATION OF SPOIL BANKS IN CENTRAL PENNSYLVANIA. Ecology 36:417-423.
- Bramble, W. C., and M. K. Goddard.
1943. SEASONAL BROWSING OF WOODY PLANTS BY WHITE-TAILED DEER IN THE BEAR-OAK FOREST TYPE. J. Forest. 41:471-475.
- Braun, E. Lucy.
1950. DECIDUOUS FORESTS OF EASTERN NORTH AMERICA. Hafner Publ. Co., New York. 596 p.
- Braun, E. Lucy.
1961. THE WOODY PLANTS OF OHIO. Ohio State Univ. Press, Columbus. 362 p.
- Bray, R. J.
1960. THE COMPOSITION OF SAVANNA VEGETATION IN WISCONSIN. Ecology 41:721-732.
- Brayton, R. D., and G. M. Woodwell.
1966. EFFECTS OF IONIZING RADIATION AND FIRE ON *Gaylussacia baccata* AND *Vaccinium vacillans*. Am. J. Bot. 53:816-820.
- Brender, E. V.
1960. PROGRESS REPORT ON CONTROL OF HONEYSUCKLE AND KUDZU. S. Weed Conf. Proc. 13. 6 p.
- Brickman, Thomas Leonard.
1950. ECOLOGY OF SPECKLED ALDER AT THE DUNBAR FOREST EXPERIMENT STATION, MICHIGAN. M. S. thesis., Mich. State Coll. 72 p.
- Bridgers, Bernard P.
1955. SOME PROPAGATION NOTES ON FLOWERING DOGWOODS FROM STEM CUTTINGS. Am. Nurseryman 101(8):14, 84-85.
- Britton, Nathaniel L.
1908. NORTH AMERICAN TREES. Henry Holt and Co., New York. 894 p.
- Brown, Bruce A.
1958. INTERRELATIONSHIPS OF BRUSH POPULATIONS AND SOME SITE FACTORS IN JACK PINE STANDS OF NORTH CENTRAL MINNESOTA. Ph.D. diss., Univ. Minn. 118 p.
- Brown, Charles P.
1946. FOOD OF MAINE RUFFED GROUSE BY SEASONS AND COVER TYPES. J. Wildl. Manage. 10:17-28.
- Brown, H. L.
1947. COACTION OF JACK RABBITS, COTTONTAIL, AND VEGETATION IN MIXED PRAIRIE. Kans. Acad. Sci. Trans. 50:28-44.
- Brown, H. P.
1922. TREES OF NEW YORK STATE NATIVE AND NATURALIZED. Syracuse Univ. Tech. Publ. 15. 433 p.
- Brown, H. P.
1938. TREES OF NORTHEASTERN UNITED STATES. Christopher Publishing House, Boston. 490 p.
- Bruner, M. H.
1967. HONEYSUCKLE—A BOLD COMPETITOR ON BOTTOMLAND HARDWOOD SITES. Forest Farmer 26(12):9, 17.
- Bruner, M. H.
1968. HONEYSUCKLE—A BOLD COMPETITOR ON BOTTOMLAND HARDWOOD SITES. Clemson Univ. Agr. Res. 14(1/2):5.
- Brunett, H. E.
1967. ESTABLISHMENT OF BROWSE. La. Pittman-Robertson Job Completion Rep. W-29-R-14, Job 8:20-22.
- Brush, Warren D.
1957. THE DOGWOODS. Am. Forests 63(4):28-29, 57-58.
- Buck, G. J.
1964. STOCK—SCION RELATIONSHIPS IN ROSES. Am. Rose Annu. 49:159-164.
- Buckman, Robert E.
1964. EFFECTS OF PRESCRIBED BURNING ON HAZEL IN MINNESOTA. Ecology 45:626-629.
- Buell, J. H.
1940. EFFECT OF SEASON OF CUTTING ON SPROUTING OF DOGWOOD. J. Forest. 38:649-650.
- Buell, Murray F., and John E. Cantlon.
1953. EFFECTS OF PRESCRIBED BURNING ON GROUND COVER IN THE NEW JERSEY PINE REGION. Ecology 34:520-528.
- Bump, Gardiner.
1950. WILDLIFE HABITAT CHANGES IN THE CONNECTICUT HILL GAME MANAGEMENT AREA. THEIR EFFECT ON CERTAIN SPECIES OF WILDLIFE OVER A TWENTY-YEAR PERIOD. Cornell Univ. Agr. Exp. Sta. Mem. 289. 75 p.
- Bump, G., R. W. Darrow, F. C. Edminister, and W. F. Crissey.
1947. THE RUFFED GROUSE. N. Y. Conserv. Dep. 915 p.
- Burger, G. V., and J. P. Linduska.
1967. HABITAT MANAGEMENT RELATED TO ROBWHITE POPULATIONS AT REMINGTON FARMS. J. Wildl. Manage. 31:1-12.
- Cain, J. C., and G. L. Slate.
1953. BLUEBERRIES IN THE HOME GARDEN. Cornell Agr. Exp. Sta. Ext. Bull. 900. 22 p.
- Callahan, K. L.
1964. X-DISEASE OF CHOKE CHERRY *Prunus virgi-*

- niana IN NEW BRUNSWICK, CANADA. USDA Plant Dis. Rep. 48(9):735.
- Camp, W. H.
1945. THE NORTH AMERICAN BLUEBERRIES WITH NOTES ON OTHER GROUPS OF VACCINIACEAE. *Brittonia* 5:203-275.
- Cantlon, J. E.
1953. VEGETATION AND MICROCLIMATES ON NORTH AND SOUTH SLOPES OF CUSHETUNK MOUNTAIN, NEW JERSEY. *Ecol. Monogr.* 23:241-270.
- Cech, F. C., and W. J. Mulder.
1964. CONTROL OF CULL HARDWOODS BY HERBICIDE INJECTION. *S. Weed Conf. Proc.* 17:240-245.
- Chadwick, L. C.
1935. PRACTICES IN PROPAGATION BY SEED. *Am. Nurseryman* 62(12):3-9.
- Chadwick, L. C.
1944. Ohio State Univ. Nursery Notes. 13:8:1-6.
- Chandler, F. B.
1943. LOWBUSH BLUEBERRIES. *Maine Agr. Exp. Sta. Bull.* 423:105-131.
- Chapman, Floyd B.
1938. THE DEVELOPMENT AND UTILIZATION OF THE WILDLIFE RESOURCES OF UNGLACIATED OHIO. Ph.D. diss., Ohio State Univ. 800 p.
- Chapman, F. B.
1947a. THE DOGWOODS IN WILDLIFE CONSERVATION. *Ohio Conserv. Bull.* 11(4):14-15.
- Chapman, Floyd B.
1947b. THE HAWTHORNS FOR WILDLIFE FOOD AND COVER. *Ohio Conserv. Bull.* 11(10):20-21.
- Chapman, F. B.
1947c. THE ROSES IN WILDLIFE CONSERVATION. *Ohio Conserv. Bull.* 11(6):20-21.
- Chapman, Floyd B.
1947d. WHAT BRAMBLES MEAN TO WILDLIFE. *Ohio Conserv. Bull.* 11(7):20-21.
- Chapman, F.
1947e. THE ELDERBERRIES IN WILDLIFE CONSERVATION. *Ohio Conserv. Bull.* 11(8):20-21.
- Chapman, Gordon L.
1950. THE INFLUENCE OF MOUNTAIN LAUREL UNDERGROWTH ON ENVIRONMENTAL CONDITIONS AND OAK REPRODUCTION. Ph.D. diss., Yale Univ. 157 p.
- Chapman, R. J., and I. R. Schneider.
1955. FUNGICIDE TESTS FOR CONTROL OF CEDAR-APPLE RUST ON HAWTHORNS. *USDA Plant Dis. Rep.* 39:985-988.
- Cheyney, E. G.
1928. THE ROOT SYSTEM OF HAZEL. *J. Forest.* 26:1046-1047.
- Clark, F. Bryan.
1962. WHITE ASH, HACKBERRY, AND YELLOW-POPLAR SEED REMAIN VIABLE WHEN STORED IN THE FOREST LITTER. *Ind. Acad. Sci. Proc.* 72:112-114.
- Clarkson, Roy B.
1959. THE WEST VIRGINIA SPIRAEA. *Castanea* 24:143-146.
- Clements, F. E.
1920. PLANT INDICATORS, THE RELATION OF PLANT COMMUNITIES TO PROCESS AND PRACTICE. *Carnegie Inst. Wash. Publ.* 290, 388 p.
- Cleveland, Jay.
1951. ARE DOGWOODS DOOMED BY DISEASE? *Am. Forests* 57:12-14.
- Clower, D. F., and J. G. Matthyse.
1955. PHYTOTOXICITY OF INSECTICIDES IN MIST SPRAY CONCENTRATE TYPE FORMULATIONS. *J. Econ. Entomol.* 47:735-738.
- Coggeshall, Roger G.
1954. PROPAGATING SOME RARER PLANTS FROM SEED. *Arnoldia* 14:25-28 (abstr.).
- Coggeshall, Roger G.
1960. WHIP AND TONGUE GRAFT FOR DOGWOODS. *Amer. Nurseryman* 111(2):9, 56, 58-59.
- Collins, Ralph P.
1960. GRAFT FAILURES OF *Cornus florida*. *Amer. Nurseryman* 112(4):12, 44.
- Comstock, J. H.
1950. AN INTRODUCTION TO ENTOMOLOGY. Comstock Publ. Co., Inc., New York. 9th ed., 1064 p.
- Conklin, H. E.
1954. TRENDS IN NEW YORK AGRICULTURE. *Cornell Univ. Dep. Agr. Econ. Forest Econ.* 196:5182-5183.
- Conway, Vernona M.
1949. THE BOGS OF CENTRAL MINNESOTA. *Ecol. Monogr.* 19:175-206.
- Cook, D. B.
1946. SUMMER BROWSING BY DEER ON CUTOVER HARDWOOD LANDS. *J. Wildl. Manage.* 10:60-63.
- Cook, D. B., and F. C. Edminster.
1944. SURVIVAL AND GROWTH OF SHRUBS PLANTED FOR WILDLIFE IN NEW YORK. *J. Wildl. Manage.* 8:185-191.
- Core, Earl L.
1929. PLANT ECOLOGY OF SPRUCE MOUNTAIN. *West Virginia Ecology* 10:1-13.
- Core, Earl L.
1966. VEGETATION OF WEST VIRGINIA. McClain Printing Co., Parsons. 217 p.
- Corzart, E. R.
1965. RECLAMATION OF MACCARTNEY ROSE INFECTED FENCE ROWS WITH TORDON HERBICIDE. *Down to Earth* 21:15-18.
- Coville, Frederick V.
1919. THE THREATENED EXTINCTION OF THE BOX HUCKLEBERRY. (*Gaylussacia brachycera*). *Sci. News Serv.* vol L. (1280):30-34.
- Cox, E. H. M., and P. A. Cox.
1956. MODERN RHODODENDRONS. Thomas Nelson and Sons, New York. 193 p.
- Crawford, H. S., Jr.
1967. STAND STOCKING AND SITE EFFECTS ON UNDERSTORY VEGETATION IN EVEN-AGED, MANAGED BLACK OAK STANDS. Ph.D. diss., Univ. Mo. 86 p.
- Crichton, V.
1963. AUTUMN AND WINTER FOODS OF THE SPRUCE GROUSE IN CENTRAL ONTARIO. *J. Wildl. Manage.* 27:597.
- Crocker, W., and L. V. Barton.
1931. AFTER-RIPENING, GERMINATION AND STORAGE OF CERTAIN ROSACEOUS SEEDS. *Boyce Thompson Inst. Contrib.* 3:385-404.
- Curlin, J. W.
1962. DOGWOOD RESPONDS TO NITROGEN FERTILIZATION. *J. Forest.* 60:718-719.
- Curtis, John T.
1959. THE VEGETATION OF WISCONSIN. Univ. Wis. Press, Madison. 657 p.
- Curtis, R. W., and Donald Wyman.
1933. WOODY PLANTS THAT TOLERATE SHADE. *N. Y. State Coll. Agr. Cornell Univ. Ext. Bull.* 268. 32 p.
- Dahlberg, B. L., and R. C. Guettinger.
1956. THE WHITE-TAILED DEER IN WISCONSIN. *Wis. Conserv. Dep. Tech. Wildl. Bull.* 14. 282 p.
- Dale, Fred H.
1956. THE FARMER AND WILDLIFE MANAGEMENT. *Soil Conserv.* 21(8):186-189.
- Dalke, Paul D.
1953. YIELDS OF SEEDS AND MAST IN SECOND GROWTH HARDWOOD FOREST, SOUTHCENTRAL MISSOURI. *J. Wildl. Manage.* 17:378-380.

- Dalke, Paul D., W. K. Clarke, Jr., and L. J. Korschgen.
1942. FOOD HABIT TRENDS OF THE WILD TURKEY IN MISSOURI AS DETERMINED BY DROPPING ANALYSIS. *J. Wildl. Manage.* 6:237-243.
- Dalke, Paul D., and Palmer R. Sime.
1941. FOOD HABITS OF THE EASTERN AND NEW ENGLAND COTTONTAILS. *J. Wildl. Manage.* 5:216-228.
- Daly, G. T.
1966. NITROGEN FIXATION BY NODULATED *Alnus rugosa*. *Can. J. Bot.* 44:1607-1621.
- Darrow, G. M.
1924. THE AMERICAN CRANBERRYBUSH. THE DOMESTICATION OF *Viburnum americanum*—A NEW FRUIT FOR THE NORTHERN UNITED STATES. *J. Hered.* 15:243-253.
- Darrow, G. M., and J. N. Moore.
1966. BLUEBERRY GROWING. *USDA Farmers' Bull.* 1951. 33 p.
- Darrow, G. M., and D. H. Scott.
1954. LONGEVITY OF BLUEBERRY SEED IN COOL STORAGE. *Am. Soc. Hort. Sci. Proc.* 63:271.
- Darrow, G. M., and G. F. Waldo.
1948. GROWING UPRIGHT AND TRAILING BLACKBERRIES. *USDA Farmers' Bull.* 1995. 34 p.
- Daubentire, R. F.
1936. THE "BIG WOODS" OF MINNESOTA: ITS STRUCTURE, AND RELATION TO CLIMATE, FIRE, AND SOILS. *Ecol. Monogr.* 6:235-268.
- Davidson, Donald W.
1965. RESPONSE OF SIX SHRUB SPECIES TO LIGHT REGIMES IN TWO CONTROLLED-ENVIRONMENT ROOMS. *Torrey Bot. Club. Bull.* 93:432-437.
- Davidson, D. W., and M. W. Buell.
1967. SHRUB AND HERB CONTINUA OF UPLAND FORESTS OF NORTHERN NEW JERSEY. *Am. Midl. Natur.* 77:371-389.
- Davis, C. A.
1943. METHODS OF GERMINATING ROSE SEEDS. *Am. Rose Mag.* 5(4):68-69.
- Davis, H. A., and Tyrecca Davis.
1953. THE GENUS *Rubus* IN WEST VIRGINIA. *Castanea* 18:1-31.
- Davis, H. A., A. M. Fuller, and T. Davis.
1967. CONTRIBUTIONS TOWARD THE REVISION OF THE EUBATI OF EASTERN NORTH AMERICA. (Part I.) *Castanea* 32:20-37.
- Davis, H. A., A. M. Fuller, and T. Davis.
1968a. CONTRIBUTIONS TOWARD THE REVISION OF THE EUBATI OF EASTERN NORTH AMERICA. (Part II.) *Castanea* 33:50-76.
- Davis, H. A., A. M. Fuller, and T. Davis.
1968b. CONTRIBUTIONS TOWARD THE REVISION OF THE EUBATI OF EASTERN NORTH AMERICA. (Part III.) *Castanea* 33:206-241.
- Davis, H. A., A. M. Fuller, and T. Davis.
1969a. CONTRIBUTIONS TOWARD THE REVISION OF THE EUBATI OF EASTERN NORTH AMERICA. (Part IV.) *Castanea* 34:157-179.
- Davis, H. A., A. M. Fuller, and T. Davis.
1970. CONTRIBUTIONS TOWARD THE REVISION OF THE EUBATI OF EASTERN NORTH AMERICA. (Part V.) *Castanea* 34:235-266.
- Davis, H. A., A. M. Fuller, and T. Davis.
1970. CONTRIBUTIONS TOWARD THE REVISION OF THE EUBATI OF EASTERN NORTH AMERICA. (Part VI.) *Castanea* 34:176-194.
- Davis, Opal Hart.
1926. GERMINATION OF SEEDS OF CERTAIN HORTICULTURAL PLANTS. *Florist and Nursery Exch.* 63:917-922.
- Davis, Opal H.
1927. GERMINATION AND EARLY GROWTH OF *Cornus florida*, *Sambucus canadensis*, AND *Berberis thunbergii*. *Bot. Gaz.* 84:225-263.
- Davis, R. B.
1966. SPRUCE-FIR FORESTS OF THE COAST OF MAINE. *Ecol. Monogr.* 36:79-94.
- Davison, V. E., and R. A. Grizzell.
1961. ATTRACTING BIRDS. *Audubon Mag.* 63:48-54.
- Day, Maurice W.
1948. THE CHEMICAL CONTROL OF CERTAIN FOREST SHRUBS: A PROGRESS REPORT. *Mich. Agr. Exp. Sta. Q. Bull.* 30:427-436.
- Day, Maurice W.
1956. A STUDY OF ALDER ON FOREST LANDS IN MICHIGAN. *Mich. Agr. Exp. Sta. Q. Bull.* 39:301-306.
- Deam, Charles C.
1932. SHRUBS OF INDIANA. *Ind. Dep. Conserv. Publ.* 44. 380 p.
- Deep, Ira W., and Allan Bartlett.
1961. COMPARISON OF STANDARD FUNGICIDES RECOMMENDED FOR CONTROL OF POWDERY MILDEW OF ROSES. *USDA Plant Dis. Rep.* 45:628-631.
- DeGarmo, W. R., and J. Gill.
1958. WEST VIRGINIA WHITETAILS. *W. Va. Conserv. Comm. Div. Game Bull.* 4. 81 p.
- Dengler, Harry W.
1957. HANDBOOK OF HOLLIES. *Nat. Hort. Mag.* 36(1):1-193.
- Detroux, L., and J. Fouarge.
1952. AN EXPERIMENT IN THE PROTECTION OF FOREST PLANTATIONS AGAINST DAMAGE FROM SMALL GAME. *Bull. Inst. Agron. Gembloux* 20(314).
- DeVisser, J.
1967. VIBURNUMS FROM SOFTWOODS. *Int. Plant Propag. Soc. Comb. Proc.* 17:259.
- DeVos, Francis.
1953. THE FLOWERING DOGWOODS. *Nat. Hort. Mag.* 32:55-56.
- DeWitt, J. B., and J. V. Derby.
1955. CHANGES IN NUTRITIVE VALUE OF BROWSE PLANTS FOLLOWING FOREST FIRES. *J. Wildl. Manage.* 19:65-70.
- Dickey, J. B.
1960. MULTIFLORA ROSE CAN BECOME A SERIOUS NUISANCE. *Am. Christmas Tree Growers' J.* 4(1):22-23.
- Dodds, D. G.
1960. FOOD COMPETITION AND RANGE RELATIONSHIPS OF MOOSE AND SNOWSHOE HARE IN NEWFOUNDLAND. *J. Wildl. Manage.* 24:52-60.
- Doehrlert, C. A.
1953. PROPAGATING BLUEBERRIES FROM HARDWOOD CUTTINGS. *N. J. Agr. Exp. Sta. Circ.* 551. 8 p.
- Doran, W. L.
1957. PROPAGATION OF WOODY PLANTS BY CUTTINGS. *Univ. Mass. Exp. Sta. Bull.* 491. 99 p.
- Dudderar, G. R.
1967. A SURVEY OF THE FOOD HABITS OF THE GRAY SQUIRREL, (*Sciurus carolinensis*) IN MONTGOMERY COUNTY, VIRGINIA. *M. S. thesis. Va. Polytech. Inst.* 72 p.
- Dugan, R. F.
1960. MULTIFLORA ROSE IN WEST VIRGINIA. *W. Va. Agr. Exp. Sta. Bull.* 477:5-34.
- Dunham, R. S.
1965. HERBICIDE MANUAL FOR NONCROPLAND WEEDS. *USDA Agr. Handb.* 269. 90 p.
- Eaton, F. L.
1949. HIGHBUSH BLUEBERRIES. *Dom. Exp. Sta. Kentville. Nova Scotia.* 1937-1946. *Rep.* 46:20-25.

- Eck, P.
1966. BOTANY. In BLUEBERRY CULTURE. Rutgers Univ. Press, New Brunswick, N. J. 378 p.
- Edminster, Frank C.
1947. THE RUFFED GROUSE. ITS LIFE STORY, ECOLOGY, AND MANAGEMENT. MacMillan Co., New York. 385 p.
- Edminster, F.
1950. USE OF SHRUBS IN DEVELOPING FARM WILDLIFE HABITAT. N. Am. Wildl. Conf. Trans. 15:519-550.
- Edminster, Frank C., and Richard M. May.
1951. SHRUB PLANTINGS FOR SOIL CONSERVATION AND WILDLIFE COVER IN THE NORTHEAST. USDA Circ. 887. 68 p.
- Eggert, F. P.
1955. INCREASING STAND OF BLUEBERRY PLANTS. In PRODUCING BLUEBERRIES IN MAINE. Maine Agr. Exp. Sta. Bull. 479:14-16.
- Egler, Frank E.
1949. HERBICIDE EFFECTS IN CONNECTICUT VEGETATION. Ecology 30:248-256.
- Eichert, J. P.
1965. PELLETED AND GRANULAR HERBICIDES FOR THE CONVERSION OF LOW VALUE HARDWOOD STANDS TO PINE. M. S. thesis, Pa. State Univ. 94 p.
- Eiser, Arthur L.
1961. SHRUBS OF VIRGINIA—TAXONOMY, ECOLOGY, AND ECONOMICS. Ph.D. diss., Va. Polytech. Inst. 373 p.
- Elwell, H. M.
1961. AERIAL AND GROUND APPLICATIONS OF HERBICIDES FOR OAK AND OTHER HARDWOOD CONTROL FOR NATIVE GRASS IMPROVEMENT OR PINE RELEASE. Okla. Agr. Exp. Sta. Process. Ser. 382 p. Stillwater.
- Engel, H.
1964. THE CONTROL OF BROOM (*Cystisus scoparius*) BY HELICOPTER. Gesunde Pflanz. 16(1):15-19.
- Engstrom, H. E., and J. H. Stoeckeler.
1941. NURSEY PRACTICE FOR TREES AND SHRUBS SUITABLE FOR PLANTINGS ON THE PRAIRIE-PLAINS. USDA Misc. Publ. 434. 159 p.
- Evenari, M., E. Konis, and D. Kirkan.
1946. THE EFFECT OF HETERAUXIN ON ROOT FORMATION BY CUTTING AND GRAFTING. Palestine J. Bot. Serv. J. 1(2):125-130.
- Everett, T. H. (Ed.).
1960. NEW ILLUSTRATED ENCYCLOPEDIA OF GARDENING. Greystone Press, New York. 342 p.
- Fernald, M. L.
1950. GRAY'S MANUAL OF BOTANY. American Book Co., New York. 8th ed., 1632 p.
- Fernald, Merritt L., and Alfred C. Kinsey.
1943. EDIBLE WILD PLANTS OF EASTERN NORTH AMERICA. Harper and Row, New York. 452 p.
- Ferrell, William K.
1953. EFFECT OF ENVIRONMENTAL CONDITIONS ON SURVIVAL AND GROWTH OF FOREST TREE SEEDLINGS UNDER FIELD CONDITIONS IN THE PIEDMONT REGION OF NORTH CAROLINA. Ecology 34:667-668.
- Fisher, P. L., A. H. Briggs, W. A. Elkins, and E. I. Roe.
1935. PROPAGATION OF GAME FOOD AND COVER PLANTS OF THE LAKE STATES. USDA Forest Serv. Lake States Forest Exp. Sta. 81 p.
- Flemion, Florence.
1938. BREAKING THE DORMANCY OF SEEDS OF *Crataegus* SPECIES. Boyce Thompson Inst. Contrib. 9:409-423.
- Fletcher, O. H., and R. E. Talbert.
1960. MULTIFLORA ROSE CONTROL WITH CHEMICALS. Weed Soc. Am.: 22-23 (Abstr.).
- Fletcher, H. H.
1960. GROWING ROSE SEEDS. Am. Rose Mag. 15(31):10.
- Fogg, John M., Jr.
1960. THE DECIDUOUS HOLLIES. Pa. Univ. Morris Arbor. Bull. 11 (4):59-63.
- Forbes, E. B., and S. I. Bechdel.
1931. MOUNTAIN LAUREL AND RHODODENDRON AS FOODS FOR THE WHITE-TAILED DEER. Ecology 12:323-333.
- Forbes, Reginald D. (Ed.).
1955. FORESTRY HANDBOOK. SEC. 9. FOREST WILDLIFE MANAGEMENT. Ronald Press Co., New York. 44 p.
- Fordham, Alfred J.
1967. SEED DISPERSAL BY BIRDS AND ANIMALS IN THE ARNOLD ARBORETUM. Arnoldia 27(10-11):73-84.
- Forestry Associates.
1970. TREE, SHRUB AND LAWN SEED CATALOG. Forest. Assoc., Allentown, Pa. 12 p.
- Fowells, H. A.
1965. SILVICS OF FOREST TREES OF THE UNITED STATES. USDA Agr. Handb. 271. 762 p.
- Free, Montague.
1957. PLANT PROPAGATION IN PICTURES. Am. Gard. Guild, Inc., and Doubleday & Co., New York. 249 p.
- Frey, J. C., K. Gertel, and A. D. Jeffrey.
1957. AN ECONOMIC APPRAISAL OF IDLE LAND IN POTTER COUNTY, NORTH CENTRAL PENNSYLVANIA. Pa. State Univ. Agr. Exp. Sta. Bull. 621. 32 p.
- Friesen, H. A.
1961. MECHANICAL CUTTING AND HERBICIDES TO CONTROL WOODY GROWTH ON NATIVE RANGE. N. Cent. Weed Control Conf. 18:100.
- Fuller, A. S.
1910. THE PROPAGATION OF PLANTS. Orange-Judd Co., New York. 349 p.
- Garrett, W. N.
1967. COMMON ROSE DISEASES. Ga. Univ. Ext. Leaf. 68:10 p.
- George, E. J.
1936. GROWTH AND SURVIVAL OF DECIDUOUS TREES IN SHELTER-BELT EXPERIMENTS AT MANDAN N. DAK. USDA Tech. Bull. 496. 48 p.
- Gibbons, Euell.
1970. STALKING THE HEALTHFUL HERBS. FIELD GUIDE EDITION. David McKay Co., New York. 303 p.
- Giersbach, J.
1937. GERMINATION AND SEEDLING PRODUCTION OF SPECIES OF VIBURNUM. Boyce Thompson Inst. Contrib. 4:27-37.
- Gilbert, E. F.
1959. THE PHENOLOGY OF *Rhus* SPECIES IN WASH-TENAW COUNTY, MICHIGAN. Ph.D. diss., Univ. Mich. 166 p.
- Gilbert, E. F.
1966. STRUCTURE AND DEVELOPMENT OF SUMAC CLONES. Am. Midl. Natur. 75:432-445.
- Gillfillan, M. C., and H. Bezdek.
1944. WINTER FOODS OF THE RUFFED GROUSE IN OHIO. J. Wildl. Manage. 8:208-210.
- Gilmer, R. M., J. D. Moore, and G. W. Keitt.
1954. X-DISEASE VIRUS: HOST RANGE PATHOGENESIS IN CHOKECHERRY. Phytopathology 44(4):180-185.
- Cleason, Henry A.
1963a. THE NEW BRITTON AND BROWN ILLUSTRATED FLORA OF THE NORTHEASTERN UNITED STATES AND ADJACENT CANADA. Hafner Publ. Co., New York. Vol. 1, 482 p.

- Gleason, Henry A.
1963b. THE NEW BRITTON AND BROWN ILLUSTRATED FLORA OF THE NORTHEASTERN UNITED STATES AND ADJACENT CANADA. Hafner Publ. Co., New York. Vol. 2, 655 p.
- Gleason, Henry A.
1963c. THE NEW BRITTON AND BROWN ILLUSTRATED FLORA OF THE NORTHEASTERN UNITED STATES AND ADJACENT CANADA. Hafner Publ. Co., New York. Vol. 3, 595 p.
- Gleason, H. A., and A. Cronquist.
1963. MANUAL OF VASCULAR PLANTS OF NORTHEASTERN UNITED STATES AND ADJACENT CANADA. Van Nostrand Co., New York. 810 p.
- Goodrum, P. D.
1940. A POPULATION STUDY OF THE GRAY SQUIRREL IN EASTERN TEXAS. Tex. Agr. Exp. Sta. Bull. 591. 34 p.
- Goodrum, P. D.
1961. GREENBRIERS. In Halls and Ripley: DEER BROWSE PLANTS OF SOUTHERN FORESTS. USDA Forest Serv. S. and SE. Forest Exp. Sta. 78 p.
- Goodwin, Richard H.
1948. HOW TO GROW DOGWOOD FROM SEED. Plant and Gard. 4:236-238.
- Gould, Walter P.
1966. THE ECOLOGY OF *Viburnum alnifolium* MARSH. Ph.D. diss., State Univ. N. Y. Coll. Forest. at Syracuse. 246 p.
- Graham, E. H.
1947. THE LAND AND WILDLIFE. Oxford Univ. Press, New York. 231 p.
- Greene, P. S.
1966. IDENTIFICATION OF THE SPECIES AND HYBRIDS IN THE LONICERA TATARICA COMPLEX. Harvard Univ. J. Arnold Arbor. 47:75-88.
- Grimm, W. C.
1951. THE BOOK OF SHRUBS. Stackpole Co., Harrisburg, Pa. 522 p.
- Grimm, W. C.
1952. THE SHRUBS OF PENNSYLVANIA. Stackpole Co., Harrisburg, Pa. 522 p.
- Grimm, W. C.
1966. THE BOOK OF TREES. Stackpole Co., Harrisburg, Pa. 493 p.
- Groves, W. J.
1952. THE GENUS *Tympanis*. Can. J. Bot. 30:571-651.
- Guillion, G. W., Ralph T. King, and William H. Marshall.
1962. MALE RUFFED GROUSE AND THIRTY YEARS OF FOREST MANAGEMENT ON THE CLOQUET FOREST RESEARCH CENTER, MINNESOTA. J. Forest. 60:617-622.
- Gunkel, W.
1965. SPROUT DAMAGE ON TATARIAN HONEYSUCKLE (*LONICERA TATARICA*) BY THE LEAF LOUSE (*HYADAPHNIS TATARICAE*) AJZENS (APHIDAE) (GI). Dtsch. Pflanzenschutzdienstes Nachrichtenbl. 17(2):24-25.
- Gysel, Leslie W.
1962. VEGETATIVE AND ANIMAL USE OF A POWER LINE RIGHT-OF-WAY IN SOUTHERN MICHIGAN. Mich. Agr. Exp. Sta. Q. Bull. 44:697-713.
- Gysel, L. W., and W. A. Lemmien.
1964. AN EIGHT-YEAR RECORD OF FRUIT PRODUCTION. J. Wildl. Manage. 28:175-177.
- Gysel, Leslie W., and Walter Lemmien.
1955. THE GROWTH AND WILDLIFE USE OF PLANTED SHRUBS AND TREES AT THE W. K. KELLOGG MULTIPLE USE FOREST. Mich. Exp. Sta. Q. Bull. 38:139-145.
- Hall, I. V.
1955. FLORISTIC CHANGES FOLLOWING THE CUTTING AND BURNING OF A WOODLOT FOR BLUEBERRY PRODUCTION. Can. J. Agr. Sci. 35:143-152.
- Hall, I. V.
1958. SOME EFFECTS OF LIGHT ON NATIVE LOWBUSH BLUEBERRIES. Am. Soc. Hort. Sci. Proc. 72:216-218.
- Hall, I. V.
1963. NOTE ON THE EFFECT OF A SINGLE INTENSIVE CULTIVATION ON THE COMPOSITION OF AN OLD BLUEBERRY STAND. Can. J. Plant Sci. 43:417-419.
- Halls, Lowell K., and Rene Alcaniz.
1965a. ROOTING CUTTINGS OF BROWSE PLANTS. USDA Forest Serv. Res. Note SO-25. 2 p.
- Halls, L. K., and R. Alcaniz.
1965b. SEASONAL TWIG GROWTH OF SOUTHERN BROWSE PLANTS. USDA Forest Serv. Res. Note SO. 23. 5 p.
- Halls, L. K., and R. Alcaniz.
1972. GROWTH PATTERNS OF DEER-BROWSE PLANTS IN SOUTHERN FORESTS. USDA Forest Serv. Res. Pap. SO-75. 14 p.
- Halls, L. K., and E. A. Epps.
1969. BROWSE QUALITY INFLUENCED BY TREE OVERSTORY IN THE SOUTH. J. Wildl. Manage. 33:1028-1031.
- Halls, L. K., F. E. Knox, and V. A. Lozar.
1957. COMMON BROWSE PLANTS OF THE GEORGIA COASTAL PLAIN: THEIR CHEMICAL COMPOSITION AND CONTRIBUTION TO CATTLE DIET. USDA Forest Serv. SE. Forest Exp. Sta. Pap. 75. 18 p.
- Halls, L. K., and S. W. Oefinger, Jr.
1969. FLOWERING DOGWOOD. La. Conserv. 21(5-6):5
- Halls, L. K., J. D. McCarty, and H. V. Wiant.
1969. RELATIVE BROWSING OF 16 SPECIES BY WHITE-TAILED DEER. J. Range Manage. 23:146-147.
- Handley, C. O.
1945. JAPANESE HONEYSUCKLE IN WILDLIFE MANAGEMENT. J. Wildl. Manage. 9:261-264.
- Hankla, Donald J.
1961. AMERICAN ELDER. In Halls and Ripley. DEER BROWSE PLANTS OF SOUTHERN FORESTS. USDA Forest Serv. and SE. Forest Exp. Sta. 78 p.
- Hardin, James W.
1966. STOCK-POISONING PLANTS OF NORTH CAROLINA. N. C. State Univ. Agr. Exp. Sta. Bull. 414. 126 p.
- Harry, G. B.
1957. WINTER FOOD HABITS OF MOOSE IN JACKSON HOLE, WYOMING. J. Wildl. Manage. 21:53-57.
- Harsberger, J. W.
1919. SLOPE EXPOSURE AND THE DISTRIBUTION OF PLANTS IN EASTERN PENNSYLVANIA. Geogr. Soc. Phila. Bull. 17:53-61.
- Hart, George, and William R. Byrnes.
1960. TREES FOR STRIP-MINED LANDS. USDA Forest Serv. NE. Forest Exp. Sta. Pap. 136. 36 p.
- Hart, Thomas B.
1951. THE ECOLOGICAL DISTRIBUTION OF THE TREES AND SHRUBS OF MEIGS COUNTY, OHIO. M. S. thesis. Ohio Univ. 72 p.
- Harlow, W. M.
1957. TREES OF THE EASTERN AND CENTRAL UNITED STATES AND CANADA. Dover Publ., New York. 288 p.
- Harlow, William M., and Ellwood S. Harrar.
1958. TEXTBOOK OF DENDROLOGY. McGraw-Hill Book Co., New York. 4th ed., 512 p.
- Harrar, E. S., and J. G. Harrar.
1946. GUIDE TO SOUTHERN TREES. McGraw-Hill Book Co., New York. 712 p.
- Harris, R. E.
1961. THE VEGETATIVE PROPAGATION OF *Amelanchier alnifolia*. Can. J. Plant. Sci. 41:728-731.

- Hartmann, Hudson T., and Dale E. Kester.
1959. PLANT PROPAGATION, PRINCIPLES AND PRACTICES. Prentice-Hall, Englewood Cliffs, N. J. 559 p.
- Hartmann, Hudson T., and Dale E. Kester.
1968. PLANT PROPAGATION: PRINCIPLES AND PRACTICES. Prentice-Hall, Englewood Cliffs, N. J. 2nd ed., 702 p.
- Haugen, Arnold O.
1942. LIFE HISTORY STUDIES OF THE COTTONTAIL RABBIT IN SW MICHIGAN. *Am. Midl. Natur.* 28:204-244.
- Hausman, Leon Augustus.
1928. WOODPECKERS, NUTHATCHES AND CREEPERS OF NEW JERSEY. *N. J. Agr. Exp. Sta. Bull.* 470. 48 p.
- Hausman, Leon Augustus.
1931. THE SYLVIDS AND FLYCATCHERS OF NEW JERSEY. *N. J. Agr. Exp. Sta. Bull.* 531. 32 p.
- Heald, F. D.
1926. MANUAL OF PLANT DISEASES. McGraw-Hill Book Co., New York. 891 p.
- Hedrick, U. P.
1908. THE GRAPES OF NEW YORK. J. B. Lyon, State Printer, Albany, N. Y. 564 p.
- Heit, C. E.
1967a. PROPAGATION FROM SEED. PART 6: HARDSEEDNESS—A CRITICAL FACTOR. *Am. Nurseryman* 125(10):10-12, 88-96.
- Heit, C. E.
1967b. PROPAGATION FROM SEED. PART 7: GERMINATING SIX HARDSEEDED GROUPS. *Am. Nurseryman* 125(12):10-12, 37-41, 44-45.
- Heit, C. E.
1967c. PROPAGATION FROM SEED. PART 8: FALL PLANTING OF FRUIT AND HARDWOOD SEEDS. *Am. Nurseryman* 126(4):12-13, 85-90.
- Heit, C. E.
1967d. PROPAGATION FROM SEED. PART 10: STORAGE METHODS FOR CONIFER SEEDS. *Am. Nurseryman* 126(8):14-15, 38-54.
- Heit, C. E.
1967e. PROPAGATION FROM SEED. PART 11: STORAGE OF DECIDUOUS TREE AND SHRUB SEEDS. *Am. Nurseryman* 126(10):12-13, 86-94.
- Heit, C. E.
1968. PROPAGATION FROM SEED. PART 15: FALL PLANTING OF SHRUB SEEDS FOR SUCCESSFUL SEEDLING PRODUCTION. *Am. Nurseryman* 128(4):8-10, 70-80.
- Heit, C. E.
1969. PROPAGATION FROM SEED. PART 18: TESTING AND GROWING SEEDS OF POPULAR *Taxus* FORMS. *Am. Nurseryman* 129(2):10-11, 118-128.
- Hennessy, T., and L. VanCamp.
1963. WINTERING MOURNING DOVES IN NORTHERN OHIO. *J. Wildl. Manage.* 27:367-373.
- Hepting, George H.
1971. DISEASES OF FOREST AND SHADE TREES OF THE UNITED STATES. *USDA Agr. Handb.* 386. 658 p.
- Heyl, D. S.
1954. A PRELIMINARY STUDY OF SHRUB INVASION IN OLD FIELDS IN CENTRAL PENNSYLVANIA. M. S. thesis. Pa. State Univ. 71 p.
- Hickie, P.
1940. COTTONTAILS IN MICHIGAN. *Mich. Dep. Conserv.* 112 p.
- Hill, A. F.
1923. THE VEGETATION OF THE PENOBSCOT BAY REGION, MAINE. *Portland Soc. Nat. Hist. Proc.* 3:307-438.
- Hirth, H. F.
1959. SMALL MAMMALS IN OLDFIELD SUCCESSION. *Ecology* 40:417-425.
- Hitchcock, A. E., and P. W. Zimmerman.
1949. EFFECT OF CONCENTRATE OF 2,4-D, RATE OF APPLICATION AND RESPRAYING OF JAPANESE HONEY-SUCKLE. *Am. Soc. Hort. Sci. Proc.* 51:668-669.
- Hitz, C. W.
1949. INCREASING PLANT STAND IN BLUEBERRY FIELDS. *Maine Agr. Exp. Sta. Bull.* 467. 27 p.
- Hodgdon, A. R.
1958. VEGETATIONAL SURVIVAL ON SOME PUBLIC UTILITY LINES IN NEW HAMPSHIRE FOLLOWING FOLIAGE SPRAYING WITH 2,4-D AND 2,4,5-T ESTERS. *NE. Weed Control Conf. Proc.* 12:239-245.
- Hodgdon, A. R., and R. Pike.
1961. AN ECOLOGICAL INTERPRETATION OF RHODODENDRON COLONIES IN MAINE, AND NEW HAMPSHIRE. *Rhodora* 62(747):61-70.
- Hodgdon, Albion R., and Frederic C. Steele.
1958. THE WOODY PLANTS OF NEW HAMPSHIRE. *N.H. Agri. Exp. Sta. Bull.* 447. 60 p.
- Holweg, Arthur W.
1964. SOME SHRUBS AND VINES FOR WILDLIFE FOOD AND COVER. *N. Y. Conserv.* 19:22-27.
- Hoover, K. B.
1961. HAWTHORN STUDIES IN PENNSYLVANIA IN RELATION TO WILDLIFE VALUES. *Pa. Coop. Wildl. Res. Unit Spec. Rep.* 5. 68 p.
- Hosley, N. W.
1938. WOODY PLANTS USED BY WILDLIFE IN THE NORTHEASTERN UNITED STATES. Ph.D. diss., Univ. Mich. 409 p.
- Hosley, N. W.
1949. THE MOOSE AND ITS ECOLOGY. *U. S. Fish and Wildl. Serv. Wildl. Leaf.* 312. 51 p.
- Hosley, N. W.
1956. MANAGEMENT OF THE WHITE-TAILED DEER IN ITS ENVIRONMENT. *In* W. P. Taylor, THE DEER OF NORTH AMERICA: 187-331. Stackpole, Harrisburg. Pa.
- Hosley, N. W., and R. K. Ziebarth.
1935. SOME WINTER RELATIONS OF THE WHITE-TAILED DEER TO THE FOREST IN CENTRAL MASS. *Ecology* 16:535-553 p.
- Hotchkiss, Neil.
1932. A BOTANICAL SURVEY OF THE TUG HILL PLATEAU. *N. Y. State Museum Bull.* 287. 123 p. Albany.
- Hottes, Alfred C.
1937. THE BOOK OF SHRUBS. A. T. De La Mare Co., New York. 438 p.
- Hottes, Alfred C.
1949. GARDEN FACTS AND FANCIES. Dodd Mead and Co., New York. 370 p.
- Hottes, Alfred Carl.
1931. THE BOOK OF SHRUBS. A. T. De La Mare Co., New York. 437 p.
- Hough, A. F.
1936. A CLIMAX FOREST COMMUNITY ON EAST TIONESTA CREEK IN NORTHWESTERN PENNSYLVANIA. *Ecology* 17:9-28.
- Hough, Romeyn B.
1907. HANDBOOK OF THE TREES OF THE NORTHERN STATES AND CANADA. Lowville, N. Y. 470 p.
- Howard, W. L.
1915. AN EXPERIMENTAL STUDY OF THE REST PERIOD IN PLANTS. *Mo. Agr. Exp. Sta. Res. Bull.* 17. 58 p.
- Hsiung, Wen Yue.
1951. AN ECOLOGICAL STUDY OF BEAKED HAZEL *Corylus cornuta* MARSH IN THE CLOQUET EXPERIMENTAL FOREST, MINNESOTA. Ph.D. diss., Univ. Minn. 117 p.
- Hulett, G. K., R. T. Coupland, and R. L. Dix.
1966. THE VEGETATION OF DUNE SAND AREAS WITHIN

- THE GRASSLAND REGION OF SASKATCHEWAN. *Can. J. Bot.* 44:1307-1331, illus.
- Inman, R. E.
1962. CYCLOHEXIMIDE AND THE CONTROL OF HAWTHORN LEAF BLIGHT UNDER NURSERY CONDITIONS. *USDA Plant Dis. Rep.* 46:827-830.
- Isely, Duane (Ed.).
1965. RULES FOR TESTING SEEDS. *Assoc. Off. Seed Anal. Proc.* 54(2):112.
- Jacklin, S. W., W. L. Jacklin, and F. F. Smith.
1966. A CURRENT LOOK AT PEST AND DISEASE CONTROL OF OUTDOOR ROSES. *Am. Rose Annu.* 51:68-72.
- Jackson, G. A. D., and J. B. Blundell.
1963. GERMINATION IN *Rosa*. *Hort. Sci.* 38:310-320.
- Jackson, L. W. R.
1952. RADIAL GROWTH OF FOREST TREES IN THE GEORGIA PIEDMONT. *Ecology* 33:336-341.
- Jepson, W. L.
1923. A MANUAL OF THE FLOWERING PLANTS OF CALIFORNIA. Univ. Calif. Press, Berkeley. 1238 p.
- Jewell, Maria E., and H. W. Brown.
1929. STUDIES ON NORTHERN MICHIGAN BOG LAKES. *Ecology* 10:427-475.
- Johnson, W. T., W. A. Sinclair, and J. A. Weidhaas, Jr.
1966. DISEASES AND INSECTS OF HAWTHORNS AND THEIR CONTROL. *N. Y. State Coll. Agr. Cornell Ext. Bull.* 1172. 12 p.
- Johnston, S.
1942. THE INFLUENCE OF VARIOUS SOILS ON THE GROWTH AND PRODUCTIVITY OF THE Highbush BLUEBERRY. *Mich. Agr. Exp. Sta. Q. Bull.* 24:3707-3710.
- Jones, G. N.
1946. AMERICAN SPECIES OF *Amelanchier*. III. *Biol. Monogr.* 20:126.
- Judkins, W.
1945. ELDERBERRY CULTURE IN OHIO. *Ohio Agr. Exp. Sta. Bull.* 30:187-189.
- Kains, M. G., and L. M. McQuesten.
1945. PROPAGATION OF PLANTS. Orange Judd Publ. Co., New York. 555 p.
- Kains, M. G., and L. M. McQuesten.
1951. PROPAGATION OF PLANTS. Orange Judd Publ. Co., New York. 639 p.
- Kammerer, E. L.
1934. WHAT DECIDUOUS SHRUBS WILL ENDURE SHADE? *Morton Arbor. Bull. Pop. Inf.* 9:9-12.
- Keammerer, W. R.
1967. THIRD SURVEY OF VEGETATION. Long Island: Suffolk Co. Area AP-10. Kabfleisch Field Res. Sta.
- Keeler, Harriet Louise.
1915. OUR NATIVE TREES. Chas. Scribner's Sons, New York. 533 p.
- Kellogg, Charles E.
1952. OUR GARDEN SOILS. MacMillan Co., New York. 232 p.
- Kender, W. J., and W. T. Brightwell.
1966. ENVIRONMENTAL RELATIONSHIPS. In BLUEBERRY CULTURE. Rutgers Univ. Press, New Brunswick, N. J. 378 p.
- Kingsbury, J. M.
1969. PHYTOTOXICOLOGY: MAJOR PROBLEMS ASSOCIATED WITH POISONOUS PLANTS. *Clin. Pharm. and Ther.* 10:163-169.
- Kittredge, J.
1938. THE INTERRELATION OF HABITAT, GROWTH RATE AND ASSOCIATED VEGETATION IN THE ASPEN COMMUNITY OF MINNESOTA AND WISCONSIN. *Ecol. Monogr.* 8:151-246.
- Kittredge, J., Jr.
1934. EVIDENCE OF THE RATE OF SUCCESSION ON STAR ISLAND, MINNESOTA. *Ecology* 15:24-35.
- Klapis, A. T., Jr.
1967. SEVEN YEARS WITH VIBURNUMS FROM SOFTWOODS. *Int. Plant Propag. Soc. Comb. Proc.* 17:249-254.
- Klug, Heinrich.
1960. ECOLOGICAL GROWTH, AND SEASONAL FACTORS IN THE 2,4-D TREATMENT OF *Corylus* SPECIES. M. S. thesis, Univ. Minn.
- Korschgen, L. J.
1966. FOODS AND NUTRITION OF RUFFED GROUSE IN MISSOURI. *J. Wildl. Manage.* 30:86-100.
- Korschgen, Leroy J.
1960. PLANTS FOR WILDLIFE. *Mo. Conserv.* 21(5):1-3.
- Korschgen, Leroy J.
1967. FEEDING HABITS AND FOODS. Chap. 7 In The wild turkey and its management. *Wildl. Soc.* 589 p. Washington, D.C.
- Kozlowski, T. T.
1960. EFFECT OF MOIST STRATIFICATION AND STORAGE IN POLYETHYLENE BAGS ON GERMINATION OF FOREST TREE SEED. *Univ. Wis. Forest Res. Note.* 59. 5 p.
- Kozlowski, T. T., and R. C. Ward.
1957. SEASONAL HEIGHT GROWTH OF DECIDUOUS TREES. *Forest Sci.* 3:168-174.
- Kramer, P. J., H. J. Oosting and C. F. Korstian.
1952. SURVIVAL OF PINE AND HARDWOOD SEEDLINGS IN FOREST AND OPEN. *Ecology* 33:427-430.
- Krefting, L. W., and E. I. Roe.
1949. ROLE OF SOME BIRDS AND MAMMALS IN SEED GERMINATION. *Ecol. Monogr.* 19:269-286.
- Krefting, L. W., H. L. Hansen, and M. H. Stenlund.
1956. STIMULATING REGROWTH OF MOUNTAIN MAPLE FOR DEER BROWSE BY HERBICIDES, CUTTING, AND FIRE. *J. Wildl. Manage.* 20:434-441.
- Krefting, L. W., M. H. Stenlund, and R. K. Seemel.
1966. EFFECT OF SIMULATED AND NATURAL DEER BROWSING ON MOUNTAIN MAPLE. *J. Wildl. Manage.* 30:481-488.
- Krochmal, A., R. S. Walters, and R. M. Doughty.
1969. A GUIDE TO MEDICINAL PLANTS IN APPALACHIA. *USDA Forest Serv. Res. Pap.* NE-138. 291 p., illus.
- Kulman, H. M.
1965. NATURAL CONTROL OF THE EASTERN TENT CATERPILLAR AND NOTES ON ITS STATUS AS A FOREST PEST. *J. Econ. Entomol.* 58(1):66-70.
- Kurmes, E. A.
1961. THE ECOLOGY OF MOUNTAIN LAUREL IN SOUTHERN NEW ENGLAND. Ph.D. diss., Yale Univ. 85 p.
- Kurmis, Vilis, Alvin Fedkenheuer, Myron Grafstrom, and Richard A. Hesse.
1970. TREE REPRODUCTION AND SHRUBS IN RELATION TO STAND AND SITE CONDITIONS IN ST. CROIX STATE PARK, MINNESOTA. *Univ. Minn. Agr. Exp. Sta. Forest Res. Note* 217. 4 p.
- Labisky, R. F., and W. L. Anderson.
1965. EFFECTS OF MULTIFLORA ROSE HEDGES ON CORN YIELDS IN ADJACENT FIELDS. *J. Wildl. Manage.* 29:192-195.
- Lamb, G. N.
1915. WILLOWS: THEIR GROWTH, USE, AND IMPORTANCE. *USDA Bull.* 316. 52 p., illus.
- Laramie, H. A., Jr.
1968. DEER FOOD. In H. R. Siegler, The whitetailed

- deer of New Hampshire: 55-58. N. H. Fish and Game Dep. Surv. Rep. 10. 256 p., illus.
- Latham, Roger M.
1950. PENNSYLVANIA'S DEER PROBLEM. Pa. Game News Spec. Issue 1. 48 p., illus.
- Laurie, Alex, and L. C. Chadwick.
1931. THE MODERN NURSERY—A GUIDE TO PLANT PROPAGATION, CULTURE AND HANDLING. MacMillan Co., New York. 494 p., illus.
- Lawrence, Donald B.
1958. GLACIERS AND VEGETATION IN SOUTHEASTERN ALASKA. Am. Sci. 46:89-122, illus.
- Lawyer, D. A.
1968. PROPAGATING *Sorbus*. Am. Nurseryman 127(2): 7, 54, 56, 60, 65.
- Lay, D. W.
1969. FOODS AND FEEDING HABITS OF WHITE-TAILED DEER. WHITE-TAILED DEER IN SOUTHERN FOREST HABITAT. USDA Forest Serv. Forest Exp. Sta. Symp. Proc. 8-13.
- Lay, Daniel W.
1956. EFFECTS OF PRESCRIBED BURNING ON FORAGE AND MAST PRODUCTION IN SOUTHERN PINE FOREST. J. Forest. 54:582-584.
- Lay, Daniel W.
1957. BROWSE QUALITY AND THE EFFECTS OF PRESCRIBED BURNING IN SOUTHERN PINE FORESTS. J. Forest. 55:342-347.
- Lay, Daniel W.
1961. FRUIT PRODUCTION OF SOME UNDERSTORY HARDWOODS. SE. Assoc. Game & Fish Comms. Proc.: 30-37.
- Lay, Daniel W.
1965a. FRUIT UTILIZATION BY DEER IN SOUTHERN FORESTS. J. Wildl. Manage. 29:370-375.
- Lay, Daniel W.
1965b. EFFECTS OF PERIODIC CLIPPING ON YIELD OF SOME COMMON BROWSE SPECIES. J. Range Manage. 18:181-184.
- Leach, David G.
1961. RHODODENDRONS OF THE WORLD. Charles Scribner and Sons, New York. 544 p.
- Leatherman, A. D.
1955. ECOLOGICAL LIFE HISTORY OF *L. japonica* THUNB. Diss. Abstr. 15(11):1987.
- Lebedeff, V.
1967. TO HASTEN THE RIPENING OF ROSE SEED. Am. Rose Annu. 52:58-59.
- Leftwich, R. L.
1952. ARTS AND CRAFTS OF THE CHEROKEE TODAY. W. Carolina Teacher's Coll. Bull. 29:1-12.
- Leonard, R. G.
1961. SASSAFRAS. In Halls and Ripley. Deer browse plants of southern forests. USDA Forest Serv. S. and SE. Forest Exp. Sta., 78 p., illus.
- Leopold, A., L. K. Sowls, and D. L. Spencer.
1947. A SURVEY OF OVERPOPULATED DEER RANGES IN THE UNITED STATES. J. Wildl. Manage. 11:162-177.
- Link, Conrad B.
1945. THE CHRISTMAS HOLLIES. Plants and Gard. n.s. 1(4):203-206.
- Liscinsky, S. A.
1960. THE AMERICAN WOODCOCK IN PENNSYLVANIA. Final report. Pittman-Robertson Proj. WSOR. 198 p.
- Liscinsky, S. A.
1963. THE PENNSYLVANIA WOODCOCK STUDY—HABITAT REQUIREMENTS. Pa. Game News 34(5):26-29.
- Liscinsky, Steve.
1965. THE AMERICAN WOODCOCK IN PENNSYLVANIA. Pa. Game Comn. 32 p., illus.
- Liscinsky, Stephen A.
1972. THE PENNSYLVANIA WOODCOCK MANAGEMENT STUDY. Pa. Game Comn. Res. Bull. 171. 95 p., illus.
- Little, E. H., Jr.
1945. MISCELLANEOUS NOTES ON NOMENCLATURE OF U. S. TREES. Amer. Midl. Natur. 33:495-531.
- Little, Elbert L., Jr.
1944. LAYERING AFTER A HEAVY SNOW STORM IN MARYLAND. Ecology 25: 112-113.
- Little, Elbert L., Jr.
1953. CHECK LIST OF NATIVE AND NATURALIZED TREES OF THE UNITED STATES (INCLUDING ALASKA). USDA Agr. Handb. 41. 472 p.
- Little, S.
1967a. JAPANESE HONEYSUCKLE: PERSISTENT USE OF HERBICIDES REQUIRED TO COMBAT THIS ROBUST IMMIGRANT. Brooklyn Bot. Gard. Handb. Weed Control 22(3):62-63. illus.
- Little, S.
1967b. RESULTS OF HERBICIDE TRAILS TO CONTROL JAPANESE HONEYSUCKLE. USDA Forest Serv. Res. Note NE-62. 8 p.
- Little, S.
1968. HERBICIDE TREATMENTS OF JAPANESE HONEYSUCKLE FOR RELEASING DESIRABLE REPRODUCTION OR FOR SITE PREPARATION. USDA Forest Serv. Res. Note NE-83. 8 p.
- Little, S., G. R. Moorhead, and H. A. Somes.
1958. FORESTRY AND DEER IN THE PINE REGION OF NEW JERSEY. NE. Forest Exp. Sta. Pap. 109. 33 p., illus.
- Lloyd, C. H., and G. W. Eley.
1955. MULTIFLORA ROSE ERADICATION. J. Soil and Water Conserv. 10:78-80.
- Landscape Materials Information Service.
1966. 27TH NURSERY REPORT. Landscape Materials Inf. Serv., New York. 131 p.
- Lovell, J. F.
1964. AN ECOLOGICAL STUDY OF *Rhus glabra*. Ph.D. diss., Kans. State Univ. 83 p.
- Longenecker, G. W., and R. Ellarson.
1960. LANDSCAPE PLANTS THAT ATTRACT BIRDS. Univ. Wis. Ext. Serv. Circ. 514. 10 p.
- Lott, T. B., and F. W. L. Keane.
1960. TWISTED LEAF VIRGIN'S INDIGENOUS IN CHOKE CHERRY. USDA Plant Dis. Rep. 44:328-330.
- Lowry, G. L., F. C. Brokaw, and C. H. J. Breeding.
1967. ALDER FOR REFORESTING COAL SPOILS IN OHIO. J. Forest. 60:196-199, illus.
- Lutz, H. J.
1930. THE VEGETATION OF HEAICT'S CONTENT, A VIRGIN FOREST IN NORTHWESTERN PENNSYLVANIA. Ecology 11:1-29.
- McAtee, W. L.
1914. HOW TO ATTRACT BIRDS IN NORTHEASTERN UNITED STATES. USDA Farmers' Bull. 621. 11 p., illus.
- McAtee, W. L.
1936. GROUPS OF PLANTS VALUABLE FOR WILDLIFE UTILIZATION AND EROSION CONTROL. USDA Circ. 412. 11 p.
- McAtee, W. L.
1956. A REVIEW OF THE NEARCTIC VIBURNUM. Chapel Hill, N. C. 125 p., illus.
- McCully, W. G.
1958. FENURON PELLET APPLICATIONS FOR OAK CONTROL. Tex. Agr. Aviat. 7th Ann. Conf. Proc. 21(3315):435.
- McDermott, R. E.
1953. LIGHT AS A FACTOR IN THE GERMINATION OF SOME BOTTOMLAND HARDWOOD SEEDS. J. Forest. 51:203-4.

- McDermott, R. F.
1954. EFFECTS OF SATURATED SOIL ON SEEDLING GROWTH OF SOME BOTTOMLAND HARDWOOD SPECIES. *Ecology* 35:36-41.
- McIntosh, R. P.
1959. PRESENCE AND COVER IN PITCH PINE-OAK STANDS OF THE SHAWANGUNK MOUNTAINS. NEW YORK. *Ecology* 40:482-485.
- McIntosh, R. P., and R. T. Hurley.
1964. THE SPRUCE-FIR FORESTS OF THE CATSKILL MOUNTAINS. *Ecology* 45:314-326.
- McKenny, Margaret.
1933. BIRDS IN THE GARDEN AND HOW TO ATTRACT THEM. Reynal and Hitchcock, New York. 349 p., illus.
- McVaugh, R.
1957. ESTABLISHMENT OF VEGETATION ON SANDFLATS ALONG THE HUDSON RIVER, NEW YORK. Part II. THE PERIOD 1945-1955. *Ecology* 38:23-29.
- MacArthur, J. D., and J. W. Fraser.
1963. LOW TEMPERATURE GERMINATION OF SOME EASTERN CANADIAN TREE SEED. *Forest. Chron.* 39:478-9.
- Magruder, N. D., C. E. French, L. C. McEwen, and R. W. Swift.
1957. NUTRITIONAL REQUIREMENTS OF THE WHITE-TAILED DEER FOR GROWTH AND ANTLER DEVELOPMENT. II. EXPERIMENTAL RESULTS OF THE THIRD YEAR. *Pa. Agr. Exp. Sta. Bull.* 628. 21 p.
- Mahlstede, John P. and Ernest S. Haber.
1957. PLANT PROPAGATION. John Wiley & Sons, New York. 413 p., illus.
- Mainland, C. M.
1966. PROPAGATION AND PLANTING. In BLUEBERRY CULTURE. Rutgers Univ. Press, New Brunswick, N. J. 378 p., illus.
- Marie-Victorin, F., and J. Rousseau.
1940. NOUVELLES ENTITIES DE LA FLORE PHANEROGAMIQUE DU CANADA ORIENTAL. *Contrib. Inst. Bot. Univ. Montreal.* 36:13.
- Marsh, C. Dwight.
1930. MOUNTAIN-LAUREL (*Kalmia latifolia*) AND SHEEP LAUREL (*Kalmia angustifolia*) AS STOCK-POISONING PLANTS. USDA Tech. Bull. 219. 22 p., illus.
- Martin, A. C., Franklin H. May, and Talbott E. Clarke.
1939. EARLY WINTER FOOD PREFERENCES OF THE WILD TURKEY ON THE GEORGE WASHINGTON NATIONAL FOREST. *N. Am. Wildl. Conf. Trans.* 4:570-578.
- Martin, A. C., H. S. Zim, and A. L. Nelson.
1951. AMERICAN WILDLIFE AND PLANTS. McGraw-Hill Book Co., New York. 500 p., illus.
- Martin, A. C., and W. D. Barkley.
1961. SEED IDENTIFICATION MANUAL. Univ. Calif. Press., Berkeley. 160 p.
- Martin, E. C.
1966. HONEY BEE POLLINATION OF THE HIGHBUSH BLUEBERRY. *Am. Bee J.* 106:366-67, illus.
- Marucci, P. E.
1966. BLUEBERRY POLLINATION. *Am. Bee J.* 106:250-251, 264, illus.
- Mason, C. R.
1945. BUILD BIRD POPULATIONS WITH FOOD PLANTS. *Arnoldia* 5:5-20.
- Massey, A. B.
1945. NATIVE GRAPES. Va. Polytech. Inst. Bull. 38(9):1-20.
- Massey, A. B.
1961. SUMMER GRAPE. In DEER BROWSE PLANTS OF SOUTHERN FORESTS. USDA Forest Serv. S. and SE. Forest Exp. Sta. 77 p., illus.
- Massey, A. B. and C. R. Ball.
1944. THE WILLOWS OF VIRGINIA. Va. Polytech. Inst. Bull. 37(9):31.
- Mathews, F. S.
1915. FIELD BOOK OF AMERICAN TREES AND SHRUBS. G. P. Putnam's Sons, New York. 537 p.
- Mattoon, H. G. (Editor).
1958. PLANT BUYER'S GUIDE OF SEED AND PLANT MATERIALS IN THE TRADE. Mass. Hort. Soc., Boston. Ed. 6. 298 p.
- May, Curtis.
1965. RUST OF JUNIPER, FLOWERING CRAB APPLE AND HAWTHORN. *Am. Hort. Mag.* 44(1):29-32.
- Meagher, Margaret M.
1958. A COMPARATIVE DEER BROWSE AND HERD DENSITY STUDY, 1949-1958 ON THE GEORGIA RESERVE. M. S. thesis., Univ. Mich. 60 p.
- Mecartney, J. L.
1945. GROWING BLACKBERRIES AND BLACK AND PURPLE RASPBERRIES IN PENNSYLVANIA. *Pa. State Coll. Agr. Exp. Circ.* 272. 18 p.
- Miller, William J.
1959. THE FLOWERING DOGWOOD ON LONG ISLAND. *New York. Nat. Hort. Mag.* 38:83-91.
- Minckler, L. S.
1941. PLANTING WHITE PINE IN LAUREL AND RHODODENDRON "SLICKS". *J. Forest.* 39:1036.
- Morey, D.
1960. SEED STRATIFICATION TECHNIQUES WITH EMPHASIS ON ROSES. *Plant Propag. Soc. Proc.* 10:267-273.
- Morrow, E. B., G. M. Darrow, and D. H. Scott.
1954. A QUICK METHOD FOR CLEANING BERRY SEED FOR BREEDERS. *Am. Soc. Hort. Sci. Proc.* 63:265.
- Mosby, H. S., and C. O. Handley.
1943. THE WILD TURKEY IN VIRGINIA: ITS STATUS, LIFE HISTORY AND MANAGEMENT. Va. *Conn. Game and Inland Fish.* 281 p.
- Moyer, Elbert L., Jr.
1967. CONTROLLING OFF-SITE HARDWOODS WITH 3,4-D AMINE CONCENTRATE. USDA Forest Serv. Res. Note SE-77. 2 p.
- Munns, E. N.
1938. THE DISTRIBUTION OF IMPORTANT FOREST TREES OF THE UNITED STATES. USDA Misc. Publ. 287. 176 p., illus.
- Murie, O. J.
1951. THE ELK OF NORTH AMERICA. Stackpole Co., Harrisburg, Pa. 376 p.
- Murphy, Dean A., and John H. Ehrenreich.
1965. FRUIT-PRODUCING TREES AND SHRUBS IN MISSOURI'S OZARK FORESTS. *J. Wildl. Manage.* 29:497-503.
- Nation, Hoyt A., and Charles T. Lichy.
1964. TORDON HERBICIDE OF BRUSH CONTROL IN THE SOUTHERN U. S. S. Weed Conf. Proc. 17:287-294.
- Natural Resources Committee of State Agencies.
1967. SELECTIVE BRUSH MANAGEMENT PROGRAM FOR WISCONSIN ROADSIDES. Wis. Conserv. Dep. Bull. 16 p. Madison.
- Neal, O. M., and Roger W. Pease.
1954. A DECIDUOUS HOLLY FOR WINTER COLOR. *Nat. Hort. Mag.* 33(3):226-230.
- Nelson, A. L., T. E. Clarke, and W. W. Bailey.
1938. EARLY WINTER FOOD OF RUFFED GROUSE ON THE GEORGE WASHINGTON NATIONAL FOREST. USDA Circ. 504. 37 p. illus.
- Nelson, M. M., J. B. Moyle, and A. T. Farnham.
1966. COBALT LEVELS IN FOOD AND LIVERS OF PHEASANTS. *J. Wildl. Manage.* 30:423-425.
- Newlon, C. F., T. S. Baskett, R. P. Breitenback, and J. A. Stanford.

1964. SUSTAINING VALUES OF EMERGENCY FOOD FOR BOBWHITES. *J. Wildl. Manage.* 28:532-542.
- Nichols, G. E.
1935. THE HEMLOCK-WHITE PINE-NORTHERN HARDWOOD REGION OF EASTERN NORTH AMERICA. *Ecology* 6:403-422.
- Nichols, George E.
1914. THE VEGETATION OF CONNECTICUT. III. PLANT SOCIETIES ON UPLANDS. *Torreya* 14(10):167-194.
- Nichols, L. P.
1958. HAWTHORN SPRAYING IN PENNSYLVANIA WITH ZINEB. *USDA Plant Dis. Rep.* 42:713.
- Niering, W. A.
1953. THE PAST AND PRESENT VEGETATION OF HIGH POINT STATE PARK, NEW JERSEY. *Ecol. Monogr.* 23:127-148.
- Niering, W. A.
1961. CONNECTICUT ARBORETUM RIGHT-OF-WAY DEMONSTRATION AREA—ITS ROLE IN COMMERCIAL APPLICATION. *NE. Weed Control Conf. Proc.* 15:424-33.
- Niering, W. A., and F. E. Egler.
1955. A SHRUB COMMUNITY OF *Viburnum lentago*, STABLE FOR TWENTY-FIVE YEARS. *Ecology* 36:356-360.
- Nixon, C. M., M. W. McClain, and K. R. Russell.
1970. DEER FOOD HABITS AND RANGE CHARACTERISTICS IN OHIO. *J. Wildl. Manage.* 34:870-886.
- Nixon, Charles M., and Milford W. McClain.
1966. FOODS OF THE WHITE-TAILED DEER IN OHIO. *Ohio Div. Wildl. Game Manage. Inserv. Note* 51. 12 p.
- Northeast Regional Technical Service Center.
1971. SOURCE OF PLANTING STOCK AND SEED OF CONSERVATION PLANTS USED IN THE NORTHEAST. *U.S.D.A. Soil Conserv. Serv., Upper Darby, Pa.* 15 p.
- Ohio Agricultural Experiment Station.
1962. MULTIFLORA ROSE POLICY IS ADOPTED. *Ohio Agr. Exp. Sta. Farm and Home Res.* 47:14.
- Oosting, H. J.
1956. THE STUDY OF PLANT COMMUNITIES. W. H. Freeman, San Francisco. 440 p., illus.
- Oosting, H. J., and J. F. Reed.
1944. ECOLOGICAL COMPOSITION OF PULPWOOD FORESTS IN NORTHWESTERN MAINE. *Am. Midl. Natur.* 31:182-210
- Oregon Agricultural Progress.
1958. WILD ROSE CAN BE CONTROLLED. *Ore. Agr. Prog.* 5(2):12-13.
- Osborn, A.
1933. SHRUBS AND TREES FOR THE GARDEN. Ward, Lock & Co., London. 576 p.
- Otis, C. H.
1960. MICHIGAN TREES. *Univ. Mich. Press, Ann Arbor.* 362 p.
- Packard, R. L.
1956. THE TREE SQUIRRELS OF KANSAS. *Univ. Kans. Museum of Natur. Hist. and State Biol. Surv.* 67 p.
- Palmer, E. Laurence.
1949. *FIELDBOOK OF NATURAL HISTORY.* McGraw-Hill Book Co., New York. 664 p., illus.
- Palmer, J. G., and T. J. Henneberry.
1961. INFLUENCE OF SURFACTANTS AND THE MITICIDE ARAMITE ON CONTROL OF ROSE BLACKSPOT BY PHALTAN. *USDA Plant Dis. Rep.* 45:652-656.
- Palmer, Walter L.
1961. A STUDY OF RUFFED GROUSE DRUMMING SITES IN NORTHERN MICHIGAN. *Mich. Dep. Conserv. Game Div. Rep.* 2337:40.
- Palmer, Walter L.
1963. RUFFED GROUSE DRUMMING SITES IN NORTHERN MICH. *J. Wildl. Manage.* 27:565-663.
- Palmiter, D. H., and E. M. Hildebrand.
1943. THE YELLOW-RED VIROSIS OF PEACH: ITS IDENTIFICATION AND CONTROL. *N. Y. State Agr. Exp. Sta. Gen. Bull.* 704:1-17.
- Park, Barry C.
1942. THE YIELD AND PERSISTENCE OF WILDLIFE FOOD PLANTS. *J. Wildl. Manage.* 6:118-121.
- Parker, Johnson.
1950. THE EFFECTS OF FLOODING ON THE TRANSPIRATION AND SURVIVAL OF SOME SOUTHEASTERN FOREST TREE SPECIES. *Plant Physiol.* 25:453-460.
- Parker, K. G., and D. H. Palmiter.
1951. SURVEY FOR X-DISEASE ON PEACH AND CHERRY IN N. Y., INCLUDING THE FIRST REPORT ON SWEET CHERRY. *USDA Plant Dis. Rep.* 35:256-258.
- Pearce, John, and Perley Spaulding.
1942. PLANT PATHOLOGY IN RELATION TO NORTHEASTERN FOREST WILDLIFE COVER. *J. Wildl. Manage.* 6:194-201.
- Pease, Roger W.
1953. GROWING FLOWERING DOGWOOD FROM SOFTWOOD CUTTINGS. *Nat. Hort. Mag.* 32:71-73.
- Peattie, Donald Cross.
1950. A NATURAL HISTORY OF TREES OF EASTERN AND CENTRAL NORTH AMERICA. *Houghton Mifflin Co., Boston.* 606 p., illus.
- Peck, James M.
1970. RELATION OF CANOPY AREA AND VOLUME TO PRODUCTION OF THREE WOODY SPECIES. *Ecology* 51:1098-1101.
- Peterson, R. L.
1955. *NORTH AMERICAN MOOSE.* *Univ. Toronto Press.* 280 p.
- Petrides, George A.
1942. RELATION OF HEDGEROWS IN WINTER TO WILDLIFE IN CENTRAL NEW YORK. *J. Wildl. Manage.* 6:261-280.
- Petrides, George A.
1958. A FIELD GUIDE TO TREES AND SHRUBS. *Houghton Mifflin Co., Boston.* 431 p.
- Phillips, R. L.
1967. FALL AND WINTER FOOD HABITS OF RUFFED GROUSE IN NORTHERN UTAH. *J. Wildl. Manage.* 31:827-829.
- Pirone, P. O., B. O. Dodge and W. H. Rickett.
1960. DISEASES AND PESTS OF ORNAMENTAL PLANTS. *Ronald Press Co., New York.* 776 p.
- Pisarcv, A. A., and K. D. Boisekova.
1965. [THE SERVICEBERRY, A PROMISING MEDICINAL PLANT.], *Tr. Alma. Atinskogo Med. Inst.* 22:307-311. (From *Ref ZH Otd Vypusk Farmakol Khimioterap Sredstva Zoksikol*, 1966, No. 5.54.391). (Trans.).
- Pogge, Franz L.
1970. ROOTING SASSAFRAS CUTTINGS. *Tree Planters' Notes* 21(2):28-29.
- Porter, Harry L., Jr., and Leon F. Silberberger.
1960. STREAMBANK STABILIZATION. *J. Soil and Water Conserv.* 15:214-216.
- Post, L. J.
1965. VEGETATIVE REPRODUCTION OF MOUNTAIN MAPLE (*Acer spicatum*). *Can. Dept. Forest. Pub.* 1097. 11 p.
- Post, L. J.
1969. VEGETATIVE REPRODUCTION OF THE CONTROL OF MOUNTAIN MAPLE. *Pulp and Pap. Mag. Can.*:115-117.
- Preston, Richard J., Jr.
1966. *NORTH AMERICAN TREES.* *M. I. T. Press, Cambridge, Mass. Rev. ed.* 395 p., illus.

- Rainey, R. S.
1949. HONEYSUCKLE: FRIEND OR FOE. Va. Wildl. 10:8, 9, 26.
- Raukin, S. and L. Trofimova.
1967. INSECTICIDES MIXED WITH FERTILIZERS. (Rus) Zashch Rast. 1:50.
- Rehder, Alfred.
1940. MANUAL OF CULTIVATED TREES AND SHRUBS. MacMillan Co., New York. Ed. 2. 996 p., illus.
- Reiners, W. A.
1965. ECOLOGY OF A HEATH-SHRUB SYNUSIA IN THE PINE BARRENS OF LONG ISLAND, NEW YORK. Torrey Bot. Club. Bull. 92:448-464.
- Reiners, W. A.
1967. RELATIONSHIPS BETWEEN VEGETATIONAL STRATA IN THE PINE BARRENS OF CENTRAL LONG ISLAND. N. Y. Torrey Bot. Club Bull. 94:87-89, illus.
- Riley, Charles V.
1952. AN EVALUATION OF RECLAIMED COAL STRIP MINED LANDS AS WILDLIFE HABITAT. Ph.D. diss. Ohio St. Univ. 256 p., illus.
- Riley, Charles V.
1957. RECLAMATION OF COAL STRIP-MINED LANDS WITH REFERENCE TO WILDLIFE PLANTINGS. J. Wildl. Manage. 21:402-413.
- Ripley, Thomas H., and J. P. McClure.
1963. DEER BROWSE RESOURCES OF NORTH GEORGIA. USDA Forest Serv. Resource Bull. SE-2. 20 p. illus.
- Ritter, C. M., and G. W. McKee.
1964. THE ELDERBERRY, HISTORY, CLASSIFICATION AND CULTURE. Pa. Agr. Exp. Sta. Bull. 709:21.
- Roe, Eugene I., and Roland G. Buchman.
1963. EFFECT OF HERBICIDE, DOSAGE, AND VOLUME ON HAZEL BRUSH AT DIFFERENT FOLIAR STAGES. Forest Sci. 9:483-484.
- Rogers, J. E.
1966. THE TREE BOOK. Doubleday, Page and Co., New York. 589 p.
- Romancic, R. M.
1969. ROSEBAY RHODODENDRON—BOON OR BANE TO RESOURCES MANAGERS. Wildl. in N. C. 33(12):16-17.
- Roop, L. J.
1968. DEER HUNTING AND HERD DYNAMICS AS RELATED TO HARVEST IN CERTAIN EASTERN MAINE TOWNSHIPS. M. S. thesis. Univ. Maine, Orono. 117 p.
- Rosendahl, Carl O.
1955. TREES AND SHRUBS OF THE UPPER MIDWEST. Univ. Minn. Press. 411 p., illus.
- Rosene, Walter, Jr.
1950. SPREADING TENDENCIES OF MULTIFLORA ROSE IN THE SOUTHEAST. J. Wildl. Manage. 14:315-319.
- Ross, Bruce A., J. Roger Bray, and William H. Marshall.
1970. EFFECTS OF LONG-TERM DEER EXCLUSION ON A *Pinus resinosa* FOREST IN NORTH-CENTRAL MINNESOTA. Ecology 51:1088-1093.
- Rudolf, Paul O., and Richard F. Watt.
1956. CHEMICAL CONTROL OF BRUSH AND TREES IN THE LAKE STATES. USDA Forest Serv. Lake States Forest Exp. Sta. Pap. 41. 58 p., illus.
- Rue, Leonard Lee, III.
1964. THE WORLD OF THE BEAVER. J. P. Lippincott Co., Philadelphia. 158 p.
- Ruffner, J. D.
1965. PLANT SELECTION GUIDE FOR WEST VIRGINIA. USDA Soil Conserv. Serv. 33 p., illus.
- Sandahl, P. L.
1941. SEED GERMINATION. Parks & Recreation. 24:508.
- Sargent, Charles Sprague.
1922. MANUAL OF THE TREES OF NORTH AMERICA. Univ. Ill. Press. 610 p., illus.
- Sargent, Charles S.
1949. MANUAL OF THE TREES OF NORTH AMERICA (EXCLUSIVE OF MEXICO). Dover Publ., New York. 910 p., illus.
- Schilling, E. A.
1938. MANAGEMENT OF WHITE-TAILED DEER ON THE PISGAH NATIONAL GAME PRESERVE—SUMMARY OF FIVE-YEAR STUDY. N. Am. Wildl. Conf. Trans. 3:248-255.
- Schlutz, G.
1964. SOME PROBLEMS OF PLANTING UNDER EXTREME CONDITIONS. Dansk Skovforen. Tidsskr. 49(3):79-98.
- Schneider, E. O.
1959. A PROGRESS REPORT ON SIMAZINE FOR CONTROLLING WEEDS IN FOREST AND NURSERY PLANTINGS. NE Weed Control Conf. Proc. 13:367-371.
- Schorger, A. W.
1966. THE WILD TURKEY. Univ. Okla. Press. 625 p., illus.
- Schread, John C.
1957. THE DOGWOOD BORER. Gard. J. 7:49.
- Schread, John C.
1964. DOGWOOD CLUB GALL. Conn. Agr. Exp. Sta. Circ. 225. 6 p.
- Schumacher, F. W.
1962. HOW TO GROW SEEDLINGS OF TREES AND SHRUBS. Privately published, Sandwich, Mass. 14 p.
- Scoggan, H. J.
1950. FLORA OF BIC AND THE GASPE PENINSULA QUEBEC. Edmond Cloutier, Ottawa. Printer to Controller of Stationery. 399 p.
- Scott, Robert F.
1965. PROBLEMS OF MULTIFLORA ROSE SPREAD AND CONTROL. N. Am. Wildl. Conf. Trans. 30:360-378.
- Semeniuk, P., R. W. Stewart, and J. Uhring.
1963. INDUCED SECONDARY DORMANCY OF ROSE *R. setigera* EMBRYOS. Am. Soc. Hort. Sci. Proc. 83:825-828.
- Shadow, Hoskins A.
1959. THE BUDDING OF DOGWOOD IN THE FIELD. Plant Propag. Soc. Proc. 9:54-56.
- Shanks, R. E.
1954. REFERENCE LISTS OF NATIVE PLANTS OF THE GREAT SMOKEY MOUNTAINS. Univ. Tenn. Bot. Dep. 17 p.
- Sharp, W. M.
1965. HAWTHORNS—MULTIPLE USE SHRUBS. Cornell Plantations 21(2):19-22.
- Sheaf, Wilfrid G.
1953. PROPAGATION OF TREES, SHRUBS AND CONIFERS. MacMillan and Co., London. 479 p., illus.
- Shelford, Victor E.
1963. THE ECOLOGY OF NORTH AMERICA. Univ. Ill. Press. Urbana. 610 p., illus.
- Shepherd, Roy E.
1945. GERMINATING ROSE SEEDS. Am. Rose Annu. 121-122.
- Shepherd, Roy E.
1954. HISTORY OF THE ROSE. MacMillan Co., New York. 264 p.
- Shipman, R. D., and J. B. Schmitt.
1971. TIMBER, WILDLIFE IMPROVED WITH FENURON HERBICIDE. Pa. State Univ. Sci. in Agr. 19(1):2-3.
- Shomon, J. J.
1957. THE AMAZING WILLOW. Va. Wildl. 18(12):5-8.

- Shreve, F., M. A. Chrysler, F. H. Blodgett, and F. W. Besley.
1910. THE PLANT LIFE OF MARYLAND. Md. Weather Serv. 3 vol.
- Shutak, V. G., and P. E. Marucci.
1966. PLANT AND FRUIT DEVELOPMENT. In BLUEBERRY CULTURE. Rutgers Univ. Press, New Brunswick, N. J. 378 p., illus.
- Shutts, L. M.
1968. AUTECOLOGY AND FRUIT PRODUCTION OF *Vitis aestivalis* (SUMMER GRAPE) AND *V. aestivalis* var. *argentifolia* (SILVERLEAF GRAPE) IN THE VIRGINIA HIGHLANDS. M. S. thesis. Va. Polytech. Inst. 51 p.
- Silver, H., and N. F. Coloves.
1957. NUTRITIVE EVALUATION OF SOME FORAGE RATIONS OF DEER. N. H. Fish and Game Dep. Tech. Circ. 15. 56 p.
- Sluder, Earl R.
1958. CONTROL OF CULL TREES AND WEED SPECIES IN HARDWOOD STANDS. USDA Forest Serv. SE. Forest Exp. Sta. Pap. 95. 13 p., illus.
- Sluder, Earl R.
1961. EXPLORATORY STUDIES ON CHEMICAL CONTROL OF UNWANTED HARDWOODS IN THE SOUTHERN APPALACHIANS. USDA Forest Serv. SE. Forest Exp. Sta. Res. Note 165. 2 p.
- Smith, A. W., A. R. Hodgdon, and E. R. Eggert.
1947. PROGRESS REPORT ON CHEMICAL WEED CONTROL IN BLUEBERRY FIELDS. Am. Soc. Hort. Sci. Proc. 50:233-238.
- Smith, B. C.
1952. NURSERY RESEARCH AT OHIO STATE. Am. Nurseryman. 95:15. 94-96.
- Smith, F. H., K. C. Beeson, and W. E. Price.
1956. CHEMICAL COMPOSITION OF HERBAGE BROWSED BY DEER IN TWO WILDLIFE MANAGEMENT AREAS. J. Wildl. Manage. 20:359-367.
- Smith, H.
1946. TATARIAN HONEYSUCKLE FOR THE BEEMAN. Beekeepers Item 30:125.
- Smith, H. K.
1970. THE BIOLOGY, WILDLIFE USE AND MANAGEMENT OF SUMAC IN A STUDY AREA IN NORTHERN LOWER MICHIGAN. Ph.D. diss., Mich. State Univ. 75 p.
- Smith, J. G.
1952. FOOD HABITS OF MULE DEER IN UTAH. J. Wildl. Manage. 16:148-155.
- Smith, R. C.
1963. SOME ASPECTS OF VARIATION IN GROWTH AND DEVELOPMENT OF RHODODENDRON MAXIMUM L. IN WESTERN NORTH CAROLINA. M. S. thesis, N. C. State Coll. 63 p., illus.
- Smith, Ralph H.
1962. SOME EXPERIMENTAL SHRUB PLANTINGS—TWENTY YEARS AFTER. NE Fish and Wildl. Conf. Proc. 16 p., illus.
- Smith, Ralph H.
1964. SOME EXPERIMENTAL SHRUB PLANTINGS—20 YEARS LATER. N. Y. Fish and Game J. 11:91-105.
- Smithberg, Margaret.
1964. PATTERNS OF VARIATION AMONG SOME CLIMATIC RACES OF RED-OSIER DOGWOOD. M. S. thesis, Univ. Minn. 137 p., illus.
- Smithberg, Margaret, and Conrad J. Weiser.
1968. PATTERNS OF VARIATION AMONG CLIMATIC RACES OF RED-OSIER DOGWOOD. Ecology 49:495-505.
- Society of American Foresters.
1967. FOREST COVER TYPES OF NORTH AMERICA. Soc. Am. Forest, Washington, D.C. 67 p.
- Solomon, James D.
1968. CERAMBYCID BORER IN MULBERRY. J. Econ. Entomol. 61:1023-1025.
- Spector, W. S. (editor).
1956. HANDBOOK OF BIOLOGICAL DATA. W. B. Saunders Co., Philadelphia. 584 p.
- Spinner, George P., and George F. Ostrom.
1945. FIRST FRUITING OF WOODY PLANTS IN CONNECTICUT. J. Wildl. Manage. 9:79.
- Spurway, C. H.
1941. SOIL REACTION (pH) PREFERENCES OF PLANTS. Mich. State Coll. Agr. Exp. Sta. Spec. Bull. 306. 36 p.
- Stallard, H.
1929. SECONDARY SUCCESSION IN CLIMAX FOREST FORMATIONS OF NORTHERN MINNESOTA. Ecology 10:476-547.
- Stelfox, J. G.
1962. EFFECTS ON BIG GAME OF HARVESTING CONIFEROUS FORESTS IN WESTERN ALBERTA. Forest. Chron. 38:94-107.
- Stephenson, S. N.
1965. VEGETATION CHANGE IN THE PINE BARRENS OF NEW JERSEY. Torrey Bot. Club. Bull. 92:102-114.
- Stickel, Paul W.
1935. FOREST FIRE DAMAGE STUDIES IN THE NORTHEAST. J. Forest. 33:595-598.
- Stone, Margaret H.
1944. SOIL REACTION IN RELATION TO DISTRIBUTION OF NATIVE PLANT SPECIES. Ecology 25:379-386.
- Strausbaugh, P. D., and Earl L. Core.
1952-64. FLORA OF WEST VIRGINIA. Parts I to IV. W. Va. Univ. Bull. 1,075 p.
- Strausbaugh, P. D., E. L. Core, and Nelle Ammons.
1931. COMMON SEED PLANTS OF THE MID-APPALACHIAN REGION. Morgantown Printing and Binding Co., Morgantown, W. Va. 305 p., illus.
- Strong, F. C.
1960. CONTROL OF HAWTHORN LEAF BLIGHT. USDA Plant Dis. Rep. 44:396-398.
- Strong, F. C., and Wm. Klomparens.
1955. THE CONTROL OF RED CEDAR-APPLE AND HAWTHORN RUSTS WITH ACTIDIONE. USDA Plant Dis. Rep. 39:569.
- Stupka, A.
1964. TREES, SHRUBS, AND WOODY VINES OF THE GREAT SMOKEY MOUNTAINS NATIONAL PARK. Univ. Tenn. Press, Knoxville. 186 p., illus.
- Sucoff, Edward, and William Bailey.
1971. RELATIVE TOLERANCES OF WOODY PLANTS GROWN IN MINNESOTA TO FIVE AIR POLLUTANTS—A COMPILATION OF RATINGS. Minn. Forest. Res. Note 227. 4 p.
- Svejda, F. J., and P. W. Voisey.
1962. NOTE ON METHOD FOR SCARIFYING ROSE SEEDS. Can. J. Plant Sci. 42:383-385.
- Swank, W. G.
1944. GERMINATION OF SEEDS AFTER INGESTION BY RING-NECKED PHEASANTS. J. Wildl. Manage. 8:223-231.
- Sweetman, Harvey L.
1944. SELECTION OF WOODY PLANTS AS WINTER FOOD BY THE COTTONTAIL RABBIT. Ecology 25:467-472.
- Sweetman, Harvey L.
1949. FURTHER STUDIES OF THE WINTER FEEDING HABITS OF COTTONTAIL RABBITS. Ecology 30:371-376.
- Swingle, Charles F.
1939. SEED PROPAGATION OF TREES, SHRUBS, AND FORBS FOR CONSERVATION PLANTING. USDA Soil Conserv. Serv. TP-27. 197 p.
- Tappeiner, John C., II.
1971. INVASION AND DEVELOPMENT OF BEAKED HAZEL IN RED PINE STANDS IN NORTHERN MINNESOTA. Ecology 52:514-519.

- Taylor, Norman.
1948. ENCYCLOPEDIA OF GARDENING. Houghton-Mifflin Co., Boston. 1225 p., illus.
- Taylor, N.
1962. TAYLOR'S GARDEN GUIDE. Dell Publ. Co., New York. 448 p., illus.
- Taylor, W. P.
1961. THE DEER OF NORTH AMERICA. Stackpole Co. and Wildl. Manage. Inst. 668 p.
- Taylorson, R., and L. Holm.
1958. WEED CONTROL IN CONIFEROUS NURSERY STOCK. Annu. N. Cent. Weed Control Conf. Proc. 15:125.
- Thilenius, J. F.
1960. FORAGE UTILIZATION BY CATTLE AND WHITE-TAILED DEER ON A NORTHERN IDAHO FOREST RANGE. M. S. thesis. Univ. Idaho. 87 p., illus.
- Thomas, William Arthur Jr.
1967. ACCUMULATION AND CYCLING OF CALCIUM BY FLOWERING DOGWOOD TREES. Diss. Abstr. Sect. B 28(6):22(89 B).
- Thornthwaite, C. W.
1931. THE CLIMATES OF NORTH AMERICA ACCORDING TO A NEW CLASSIFICATION. Geogr. Rev. 21:633-655.
- Titus, Gerald R.
1940. SO-CALLED 2-YEAR SEEDS GERMINATED FIRST YEAR. Am. Nurseryman 72(11):22.
- Townsend, M. T., and M. W. Smith.
1933. THE WHITE-TAILED DEER OF THE ADIRONDACKS. PART I. PRELIMINARY SURVEY OF THE WHITE-TAILED DEER OF THE ADIRONDACKS. Roosevelt Wildl. Bull. 6. 385 p.
- Trevett, M. F.
1960. CONTROL OF SWEETFERN AND POPLAR IN LOW BLUEBERRIES BY CONTACT APPLICATION OF 2,4-D AND 2,4,5-T. NE. Weed Control Conf. Proc. 14:221-227.
- Trevett, M. F.
1962. NUTRITION AND GROWTH OF THE LOWBUSH BLUEBERRY. Maine Agr. Exp. Sta. Bull. 605. 151 p., illus.
- Trippensee, R. E.
1938. FOOD RELATIONSHIPS OF THE COTTONTAIL RABBIT IN SOUTHERN MICHIGAN. N. Am. Wildl. Conf. Trans. 3:794-804.
- Trippensee, R. E.
1948. WILDLIFE MANAGEMENT. McGraw-Hill Book Co., New York. 479 p.
- Ullrey, D. E., W. G. Youatt, H. G. Johnson, P. K. Ku, and L. D. Fay.
1964. DIGESTIBILITY OF CEDAR AND ASPEN BROWSE FOR WHITE-TAILED DEER. J. Wildl. Manage. 28:791-797.
- Ullrey, D. E., W. G. Youatt, H. E. Johnson, L. D. Fay, and B. E. Brent.
1967. DIGESTIBILITY OF CEDAR AND BALSAM FIR BROWSE FOR THE WHITE-TAILED DEER. J. Wildl. Manage. 32:162-171.
- U. S. Department of Agriculture.
1941. CLIMATE AND MAN. USDA Yearb. Agr. 1248 p., illus.
- U. S. Department of Agriculture.
1961a. SEEDS. USDA Yearb. Agr. 591 p.
- U. S. Department of Agriculture.
1961b. CHEMICAL CONTROL OF BRUSH AND TREES. USDA Bull. 2158. 23 p.
- U. S. Department of Agriculture.
1967. GROWING HOLLIES. USDA Home and Gard. Bull. 130. 8 p.
- U. S. Forest Service.
1948. WOODY-PLANT SEED MANUAL. USDA Misc. Publ. 654. 416 p., illus.
- U. S. Forest Service.
1965. SILVICS OF FOREST TREES OF THE UNITED STATES. USDA Agr. Handb. 271. 762 p., illus.
- U. S. Forest Service.
1972. SEED AND PLANTING STOCK DEALERS. USDA Forest Serv. 26 p.
- Van Dersal, W. R.
1942. ORNAMENTAL AMERICAN SHRUBS. Oxford Univ. Press, New York. 288 p., illus.
- Van Dersal, William R.
1938. NATIVE WOODY PLANTS OF THE UNITED STATES. THEIR EROSION-CONTROL AND WILDLIFE VALUES. USDA Misc. Publ. 303. 362 p., illus.
- Vermeulen, J. P.
1959. PROPAGATION OF WOODY ORNAMENTALS UNDER MIST IN PEATMOSS POTS. Plant Propag. Soc., Proc. 9:207-210.
- Verts, B. J.
1957. THE POPULATION AND DISTRIBUTION OF TWO SPECIES OF *Peromyscus* ON SOME ILLINOIS STRIP-MINED LAND. J. Mammal. 38(1):53-59.
- Viala, P., and L. Ravaz.
1903. AMERICAN VINES. Freygang-Leary Co., San Francisco. 299 p.
- Vimmerstedt, John P.
1957. SILVICAL CHARACTERISTICS OF FLOWERING DOGWOOD. USDA Forest Serv. SE. Forest Exp. Sta. Pap. 87. 11 p.
- Vincent, A. B.
1964. GROWTH AND NUMBERS OF SPECKLED ALDER FOLLOWING LOGGING OF BLACK SPRUCE PEATLANDS. Forest. Chron. 40:515-518.
- Vincent, A. B.
1965. GROWTH HABITS OF MOUNTAIN MAPLE IN THE ONTARIO CLAYBELT. Forest. Chron. 41:330-344.
- Vines, Robert A.
1960. TREES, SHRUBS AND WOODY VINES OF THE SOUTHWEST. Univ. Tex. Press. 1104 p., illus.
- Wahlenberg, W. G.
1950. FROM BRUSH TO PINE; HOW TO CONVERT RHODODENDRON BRUSH AREAS TO STANDS OF WHITE PINE TIMBER. S. Lumberman 180(2261):40-41, illus.
- Wahlenberg, W. G., and W. T. Doolittle.
1950. RECLAIMING APPALACHIAN BRUSH LANDS FOR ECONOMIC FOREST PRODUCTION. J. Forest. 48:170-174.
- Wainio, W. W., and E. B. Forbes.
1941. THE CHEMICAL COMPOSITION OF FOREST FRUITS AND NUTS FROM PENNSYLVANIA. J. Agr. Res. 62:627-635.
- Watts, C. R.
1964. FORAGE PREFERENCES OF CAPTIVE DEER WHILE FREE RANGING IN A MIXED OAK FOREST. M. S. thesis. Pa. State Univ. 65 p.
- Watts, May T.
1946. HAWTHORN TRAITS. Morton Arbor. Bull. 21(4):17-20.
- Weaver, J. E.
1919. ECOLOGICAL RELATIONS OF ROOTS. Carnegie Inst. Wash. Publ. 286. 128 p.
- Webb, W. L.
1959. SUMMER BROWSE PREFERENCES OF ADIRONDACK WHITE-TAILED DEER. J. Wildl. Manage. 23:455-456.
- Webb, William L., and Earl F. Patric.
1956. SEED-SOURCE PLANTINGS FOR HABITAT IMPROVEMENT IN NORTHEASTERN FORESTS. NE. Section Wildl. Soc. Proc: 8 p.
- Webster, H. V.
1950. COMPARATIVE STUDIES OF AMMONIUM SULFAMATE, BORAX, AND HONEYSUCKLE IN THE NATIONAL

- CAPITOL PARKS, WASH., D. C. Am. Soc. Hort. Sci. Proc. 54:513-522.
- Wells, James.
1955. PLANT PROPAGATION PRACTICES. MacMillan Co., New York. 344 p., illus.
- Wendel, George W.
1966. AERIAL SPRAYING OF LOW-GRADE HARDWOOD STANDS WITH 2,4,5-T IN WEST VIRGINIA. USDA Forest Serv. Res. Note NE-45. 4 p.
- Wenger, Karl F.
1956. GROWTH OF HARDWOODS AFTER CLEAR-CUTTING LOBLOLLY PINE. Ecology 37:735-742.
- Westcott, Cynthia.
1951. DISEASES AND PESTS OF DOGWOOD TREES. Plants and Gard. 7:136-137.
- Wherry, E. T.
1920. SOIL TESTS OF ERICACEAE AND OTHER REACTION-SENSITIVE FAMILIES IN NORTHERN VERMONT AND NEW HAMPSHIRE. Rhodora 22:33-49.
- Wherry, Edgar T.
1934. THE BOX HUCKLEBERRY AS AN ILLUSTRATION OF THE NEED FOR FIELD WORK. Torrey Bot. Club. Bull. 61(2):81-84.
- Wherry, Edgar T.
1957. SOIL ACIDITY PREFERENCES OF SELECTED WOODY PLANTS. Univ. Pa. Morris Arb. Bull. 8:19-20.
- Wiegand, Karl.
1909. RECOGNITION OF *Corylus rostrata* AND *C. americana*. Rhodora 11:107.
- Wiegel, C. A., and L. G. Baumhofer.
1948. HANDBOOK ON INSECT ENEMIES OF FLOWERS AND SHRUBS. U. S. Dep. Agr. Misc. Publ. 626:46-47.
- Wilde, S. A.
1933. THE RELATION OF SOILS AND FOREST VEGETATION OF THE LAKE STATES REGION. Ecology 14:94-105.
- Wilde, S. A.
1946. SOIL FERTILITY STANDARDS FOR GAME FOOD PLANTS. J. Wildl. Manage. 10:77-81.
- Wisconsin Conservation Department.
1967. SELECTIVE BRUSH MANAGEMENT PROGRAM FOR WISCONSIN ROADSIDES. Natur. Resources Comm. State Agencies. 16 p.
- Wistendahl, Warren A.
1958. THE FLOOD PLAIN OF THE RARITAN RIVER, NEW JERSEY. Ecol. Monogr. 28:129-153.
- Wister, John C.
1950. THE DOGWOODS. Plants and Gard. 6:48-52.
- Woestemeyer, V. W.
1963. THE USE OF GRANULAR BORATE TBA—FORMULATIONS FOR WOODY PLANT CONTROL. S. Weed Conf. Proc. 16:326-327.
- Wolfe, H. R.
1955. TRANSMISSION OF THE WESTERN X-DISEASE VIRUS BY THE LEAF HOPPER, *Colladonus montanus* (VAN D.). USDA Plant Dis. Rep. 39:298-299.
- Wolgast, Leonard J.
1972. MAST PRODUCTION IN SCRUB OAK ON THE COASTAL PLAIN IN NEW JERSEY. Ph.D. thesis. Rutgers University, New Brunswick.
- Wood, G. W., and J. S. Lindzey.
1967. THE EFFECTS OF FOREST FERTILIZATION ON THE CRUDE PROTEIN, CALCIUM, AND PHOSPHORUS CONTENT OF DEER BROWSE IN A MIXED OAK FOREST. Can. Natur. 94:335-346.
- Worley, D. P., W. C. Bramble, and W. R. Byrnes.
1957. INVESTIGATIONS OF THE USE OF 2,4,5-T ESTERS AS A BASAL SPRAY IN THE CONTROL OF BEAR OAK. Weeds 5(2):121-132.
- Wright, Thomas, Jr.
1941. A STUDY OF THE FALL FOOD SUPPLY OF THE RING-NECKED PHEASANT AND THE BOBWHITE QUAIL IN WASHINGTON COUNTY, RHODE ISLAND. J. Wildl. Manage. 5:279-296.
- Wright, W. F.
1915. NATIVE AMERICAN SPECIES OF *Prunus*. USDA Bull. 179. 75 p., illus.
- Wyman, D.
1955. VINES FOR WINTER BEAUTY. Plants and Gard. 10:46-50, illus.
- Wyman, Donald.
1966. SHRUBS AND VINES FOR AMERICAN GARDENS. MacMillan Co., New York. 442 p.
- Yawney, Harry W.
1962. CONTROL OF RHODODENDRON BY BASAL SPRAY. USDA Forest Serv. NE. Forest Exp. Sta. Forest Res. Note 132. 7 p., illus.
- Young, V. A., and G. F. Payne.
1948. UTILIZATION OF "KEY" BROWSE SPECIES IN RELATION TO PROPER GRAZING PRACTICES IN WESTERN CUTOVER WHITE PINE LANDS IN NORTHERN IDAHO. J. Forest. 46:35-40.
- Youngken, H. B.
1932. THE HISTORY, BOTANY, AND PHARMACOGNOSY OF *Viburnum opulus* L. VAR. *americanum* (MILLER) AITON. J. Am. Pharm. Assoc. 21:44-462.
- Youngken, H. B., and J. C. Munch.
1940. THE PHARMACOGNOSY AND PHARMACOLOGY OF *Viburnum alnifolium*. J. Am. Pharm. Assoc. 29:439-447.
- Ziegler, H., and R. Huser.
1963. FIXATION OF ATMOSPHERIC NITROGEN BY ROOT NODULES OF *Comptonia peregrina*. Nature 199(4892):508.
- Zorb, Gordon.
1966. SHRUBS FOR WILDLIFE HABITAT IMPROVEMENT IN SOUTHERN MICHIGAN. Mich. Dep. Conserv., Res. and Develop. Rep. 81. 14 p.
- Zucker, Isabel.
1966. FLOWERING SHRUBS. D. Van Nostrand Co., Princeton, N. J. 380 p.

GLOSSARY

This glossary has been prepared to aid readers who may not know some of the technical terms used.

- Axil.** The upper angle formed where a leaf or branch joins the stem.
- Bract.** A modified, reduced leaf from the axil of which a flower or flower stem arises.
- Broadcast.** To sow seed in all directions by scattering.
- Calcareous soil.** Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly when tested with cold hydrochloric acid.
- Callus.** In plants, protective covering that forms over a wounded surface.
- Cane.** A slender woody stem usually arising directly from the ground, usually short-lived.
- Canker.** A diseased lesion of the bark and underlying tissue.
- Capsule.** A dry, splitting, usually many-seeded fruit of more than one carpel.
- Catkin.** A scaly-bracted spike of usually unisexual flowers.
- Clone.** A group of plants propagated only by vegetative or asexual means, all members of which have been derived from a single individual.
- Cotyledon.** The seed leaf or primary leaf (or leaves) in the embryo, containing stored food for the developing seedling.
- Cutting.** A severed vegetative or asexual part of a plant used in propagation.
- Deciduous.** Falling at maturity, not persistent.
- Defoliate.** To remove the leaves from a plant.
- Division.** Cutting or breaking apart the crown or other parts of a plant so as to obtain more plants.
- Dormancy.** Continued suspension of seed growth or development in the presence of external conditions favorable for germination.
- Drift, glacial.** Coarse deposits left as a result of glaciation.
- Drill.** 1. A small furrow in which seeds are planted. 2. A row of seeds planted by dribbling them into a small furrow. 3. An implement that forms a small furrow, deposits seed in dribbles, covers the seed, and packs soil over it.
- Drupe.** A stone fruit or fleshy non-splitting fruit with a bony inner layer, usually one-seeded.
- Duff.** The surface horizon of forest soils, consisting of matted dead organic matter that is only slightly decomposed, and of humus.
- Endosperm.** The nutritive tissue of seeds, in which the embryo is embedded.
- Exotic.** Introduced, alien.
- Forb.** Any broad-leaved herbaceous plant that is not grass-like.
- Fungicide.** Any chemical that inhibits or kills fungi.
- Germination.** The development of the seedling from the seed; sprouting.
- Germination, potential.** Number of seeds germinating, plus the number of sound seeds ungerminated at the close of the test, expressed in percent of the total number of seeds tested.
- Germinative capacity.** The percentage of seed that actually germinates, regardless of time.
- Humus.** 1. In soil, organic matter that has reached an advanced stage of decomposition. 2. Any organic matter in the surface layer of soil.
- Inflorescence.** A cluster of flowers and the manner in which individual flowers are arranged.
- Involucre.** A whorl of bracts surrounding a flower cluster or a single flower or the fruits developed therefrom.
- Layer.** A stem or branch that takes root while still attached to the parent plant and tends eventually to become a separate individual plant.
- Macerate.** To separate seeds from fruit by soaking and crushing.
- Mesophytic.** Characterized by or pertaining to conditions of medium moisture supply. Syn.: Mesic.

- Naturalized.** Originally from a foreign area but now thoroughly established locally.
- Nematode.** Any round, thread-like, unsegmented worm of the phylum Nematoda.
- Node.** The place on a stem that normally bears a leaf or whorl of leaves.
- N-P-K.** Nitrogen-phosphorus-potassium.
- Ovule.** The body that becomes the seed after being fertilized.
- Perfect (flower).** One having both a functional seed-bearing organ (pistil) and pollen-bearing organs (stamens).
- Pericarp.** The wall of the ripened ovary, or fruit.
- Petiole.** A thin stem supporting the blade of a leaf.
- pH.** A scale of numbers indicating acidity or alkalinity. Some representative values are: below 4.5, extremely acid; 4.5 to 5.0, very strongly acid; 5.6 to 6.0, moderately acid; 6.6 to 7.3, neutral; 7.9 to 8.4, moderately alkaline.
- Phytotoxic.** Poisonous to plants.
- Radicle.** The portion of the embryo from which the root develops.
- Receptacle.** The swollen part of a plant stem that forms the base of a flower or an inflorescence.
- Release.** To free plants from competition by cutting, otherwise removing, or killing nearby vegetation.
- Rhizome.** Any prostrate or underground stem, usually rooting at the nodes and becoming upcurved at the apex.
- Rootstock.** In grafting, the underground stock on which parts of desirable plants are grafted.
- Rotation.** The period of years required to establish and grow trees to a specified condition of maturity.
- Runner.** A lateral above-ground shoot that may root and form young plants at some of its nodes.
- Scarification (of seed).** The wearing down by abrasion of an outer more or less impervious seed coat, to facilitate water absorption and to hasten germination.
- Scion.** A detached living portion of a plant joined to a stock in grafting.
- Soundness (of seed).** Percentage of seeds that are fully developed, or sound.
- Stolon.** A trailing or reclining stem above ground, which strikes root where it touches the soil, there sending up new shoots, which may become separate plants.
- Stratification.** The operation or method of burying seeds, often in alternate layers, in a moist medium, such as sand or peat, to overcome seed dormancy.
- Succession, plant.** The progressive development of vegetation toward its highest ecological state; replacement of one plant community by another.
- Succulent.** Juicy; having a high percentage of water.
- Sucker.** A branch or shoot from an underground stem or root that ascends above ground and tends eventually to become a separate individual plant.
- Symbiosis.** The living together of dissimilar organisms with resulting mutual benefits.
- Tolerance.** Usually, the capacity of a plant to develop and grow in shade of and in competition with trees.
- Tuber.** A swollen, fleshy portion of an underground stem or root that bears small scale-like leaves with buds.
- Vegetative reproduction.** Reproduction from plant parts other than seed.

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