Maryland Botanical Heritage Work Group

Rare and Endangered Small White Lady's Slipper, *Cypripedium candidum*

Report

For the Governor and the General Assembly of Maryland

Concerning the Preservation of Maryland's Botanical Heritage

January 15, 2014

Contents

Cover photo: By Wesley Knapp

Legislative Mandate

The Maryland Botanical Heritage Work Group was created in June 2013 (Chapter 655, Acts of 2013) to prepare a report to the General Assembly and the Governor that would define challenges, explore opportunities and make recommendations for the "preservation of plant species native to the State and the region." Authorization for the Work Group extends through May 31, 2014. The law is included as Appendix 1. Work Group members who are not state employees received no compensation for their participation. State staff were provided from among current employees. The Work Group began its work in late August after the members had been appointed by the Governor or designated by the Secretaries of their respective agencies.

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Figure 1. North Cherry Creek Bog, owned by The Nature Conservancy, is valued for its plant and animal communities, including rare and uncommon plants. Photo by Kirsten Johnson

Introduction

The preservation of Maryland's botanical heritage—and its biodiversity—requires conservation of native plants in their natural habitats. The Work Group had a broad mandate. It was to define challenges, explore opportunities, and make recommendations regarding the preservation of "plant species native to the State and region," that is, Maryland's botanical heritage. Our native plants exist in many settings: natural areas, disturbed places like roadsides and field edges, planted landscapes and gardens, and as dried specimens in herbaria. But the cornerstone of our botanical heritage is native plants in their natural habitats.

Public support for conservation of Maryland's botanical heritage is crucial. Public understanding of the importance of native plants and how they are threatened will be key to preserving our biodiversity and our botanical heritage.

Why Maryland Citizens Care about Preserving their Botanical Heritage

"[T]he loss of genetic and species diversity by the destruction of natural habitats. . . is the folly our descendants are least likely to forgive us." E.O. Wilson

The impact of human activity reaches all other living things. However, we can choose to be responsible stewards of the natural environment in which we live. Conservation of Maryland's native plants is an essential component of responsible stewardship of our State's resources. Native plants have intrinsic worth. They also serve us directly and indirectly, and are likely to serve future generations in ways that we cannot predict. For example, a thriving economy depends on healthy native plant communities, which support pollinators essential for agricultural production, provide habitats for economically important wildlife and aquatic species, protect our water supply, and provide timber and industrial products. Healthy and diverse native plant communities also have greater ecological resilience in the face of potentially changing climatic conditions.

The Ongoing Destruction of Maryland's Native Plants and Native Biodiversity

Most Maryland citizens are aware of natural areas being lost to residential, commercial, and other uses. This loss is occurring at a rapid pace to accommodate our increasing population and its preference for suburban living. What many are not aware of is that even our remaining natural

Figure 2. Spotted beebalm, Monarda punctata, *an attractive native plant that benefits native pollinators. Photo by Rochelle Bartolomei.*

areas—our forests, our meadows, and our wetlands—are severely stressed. **The idea that nature is doing fine somewhere "out there" is no longer valid.**

Plant species that once were common, that were regarded as ubiquitous as recently as the 1980s, have become uncommon in many areas. Parklands that in our lifetimes displayed a profusion of spring wildflowers do so no more. Many of our forests, including those protecting our reservoirs, are missing the understory of shrubs, tree saplings and herbaceous plants that permit forest regeneration and support animal life. Our stream banks are choked with monocultures of non-native plants and our trees are dying and falling under the weight of non-native vines. White-tailed deer are a common sight throughout Maryland, sometimes in herds of more than a dozen, each consuming many pounds of plant material a day. These trends are most pronounced in urban and suburban areas but also exist in rural areas of the Eastern Shore and western Maryland. As the plants go, so go the animals—the birds, the mammals, the reptiles, the bees and butterflies and the other insects that depend on native plants for food and shelter.

In a nutshell, we are losing our native biodiversity to habitat destruction from human activity, the invasion of non-native species, and the over-abundance of white-tailed deer. At the same time, fewer resources are devoted to preventing or alleviating the loss.

Overview of the Report

We begin with Maryland's extraordinarily rich native flora (that is, the set of all its native plants), and the geologic and historic forces that shaped it. Maryland's flora includes about 2500 species. Yet, 710 of those species, or about 28%, are now listed as rare, threatened, endangered or extinct in Maryland by the Wildlife and Heritage Service of the Department of Natural Resources. **Rare, threatened and endangered species are like the "canary in the coal mine."** Their status is an indicator of the health of the ecosystems that we share with them, and can signal the decline of animals and other plants whose existence may not yet be threatened.

The major challenges to the conservation of our native plants and their habitats include the impact from direct habitat destruction and the effects of fragmentation of natural areas. Habitat

destruction continues despite various measures at the state level designed to slow the pace of this type of loss.

In addition, our native plants are being devastated by the large numbers of white-tailed deer whose abundance is no longer kept in check. Deer consumption of native plants prevents forest regeneration and facilitates the spread of non-native invasive plants. Maryland has many areas where the majority of plant species are native, but the vast bulk of plant biomass is non-native and invasive. Restoration and landscaping practices, including by government agencies and private landowners, can either harm or help—but can never replace—our native plant diversity.

* * *

The Work Group is comprised of individuals with various affiliations and expertise, but what we have in common is that each of us spends time outdoors in Maryland, closely observing our plant and animal communities. So this Report is founded not only on the sources cited within, but on the day-to-day observations and expertise of Work Group members with many decades of collective experience. Our unanimous perception is that Maryland's natural resources—not the least of which is its botanical heritage—are under serious threat and in need of both preservation and remediation.

We are grateful to the General Assembly for recognizing the need to preserve Maryland's botanical heritage, and for giving us the opportunity to prepare a comprehensive report that focuses attention on this important subject.

Figure 3. Rare and threatened Maryland native, large purple fringed orchid, Platanthera grandiflora. *Photo by Wesley Knapp*

Executive Summary and Recommendations

Native plants in their native habitats are the foundation of the healthy ecosystems that support wildlife and a thriving economy, as well as having their own intrinsic value. Yet Maryland's extraordinarily rich native botanical heritage is under historically unprecedented stress. The main causes of the stress are habitat loss from development and other human activity, invasive non-native species, and the over-abundance of white-tailed deer.

The State agencies with responsibility for preserving our botanical heritage do their utmost to allocate limited resources in a responsible way. However, over the years, the resources available for conservation efforts by State agencies have dwindled to the point where tasks that Maryland citizens would expect to be done cannot be done.

The Work Group's recommendations identify steps that would make a positive difference to the preservation of Maryland's botanical heritage, while requiring realistic levels of additional resources or reallocations of resources.

Recommendations for improved conservation of natural habitats and listed (rare, threatened and endangered) species

To address the need for enhanced conservation of natural habitats, including those supporting rare, threatened and endangered plant species, we recommend reinforcing the foundations of the Natural Heritage Network. This is an international network that tracks and monitors species using consistent methodologies, and whose Maryland component is the Wildlife and Heritage Service (Service) within the Department of Natural Resources (DNR). These recommendations posit that static or declining budgets, at least in the Wildlife and Heritage Service, are likely to continue for the long term, given the manner in which the Service is funded. They also recognize that the Service has limited capacity for on-the-ground conservation management. Nevertheless, with modest additional resources it would be possible to accomplish significant conservation tasks.

Thus the Work Group makes the following specific recommendations:

1. **We recommend expanding the active stewardship component within the Wildlife and Heritage Service to include four regional stewards**. Many of our rare, threatened and endangered plant and animal species require habitat management to maintain and protect viable populations. Currently, the Wildlife and Heritage Service can only undertake a few high priority projects per year. Regional stewards would be chiefly responsible for on the ground monitoring and management activities in each region (Eastern, Southern, Central, Western).
2. **We recommend a short-term assistant to the State Botanist who would be responsible for assisting with updating and reviewing rank and status, annotating database records and processing herbarium data**. The Wildlife and Heritage Service employs a single full-time botanist (the State Botanist) who is responsible for setting plant conservation priorities and whose chief responsibility is maintaining the list of rare, threatened and endangered plant species. The State Botanist is continuously revising this list but progress is limited owing to additional administrative duties.

3. **We recommend assistance by a professional database management contractor (in the short term) to overhaul and eliminate the data entry backlog in Biotics that is overwhelmingly botanical in nature**. The conservation database administered by the Wildlife and Heritage Service (called "Biotics") has a critical backlog of data for entry. This database is essential to the conservation of Maryland's biodiversity.
4. **We recommend establishing a special projects fund, administered by the Wildlife and Heritage Service's Director, with allocation based upon critical inventory and monitoring gaps**. Inventory and monitoring of rare and vulnerable plant species and communities are poorly funded at present.
5. **We recommend establishing a research fund, administered by the State Botanist to address critical knowledge gaps for priority species**. At present there are no specific funds available for research specifically directed at Maryland plants.
6. **We recommend encouraging State conservation programs, including easement-based programs funded through Program Open Space, to target and design for the long-term conservation of significant botanical communities.**
7. **We recommend that DNR engage and perhaps formalize relationships with volunteer-based programs like the Maryland Master Naturalists to reduce the number of administrative hours shouldered by DNR biologists and ecologists**. Administrative and database tasks usurp the time of specially trained professional DNR staff. We caution, however, that volunteers cannot perform every task and that there will be tradeoffs between work accomplished and an increase in the workload to manage and coordinate those volunteers.
8. **We recommend that dedicated funding be allocated to the Norton Brown Herbarium at the University of Maryland, College Park in order to maintain its critical functions.** Recognizing the irreplaceable nature of the biodiversity collection and the uncertainty regarding its future, we strongly recommend that the State sustain essential funding for core staff comprising the director of the herbarium, a curator and collections manager.
9. **We recommend considering an update to the list of Nontidal Wetlands of Special State Concern**. This list, maintained by Maryland Department of the Environment, identifies nontidal wetlands that are subject to more stringent review requirements than other nontidal wetlands, often resulting in protection for rare plant species and/or high quality natural communities.

Recommendations to address the over-abundance of white-tailed deer

Effective control of white-tailed deer abundance is a necessity if we are to preserve Maryland's botanical and wildlife heritage. This challenging and complicated issue will require the cooperation of a broad range of partners including government agencies, sportsmen, farmers, and citizens seeking innovative ways to reduce deer numbers for the benefit of native habitats, suburban landscapes, the economy, public safety, and the well being of Maryland's deer herd.

The Maryland White-tailed Deer Plan 2009-2018 (here after referred to as the Plan) presents a thorough and comprehensive approach to a variety of management opportunities and techniques. The Work Group encourages DNR and other land managers (as applicable) to actively pursue these opportunities with emphasis on the following.

1. **We recommend modifications in hunting laws/regulations/practices.** This would include: season/bag limits adjustments to very localized flexibility (Community Based Deer Management), and adjusting safety zones for archery pursuits.
2. **We recommend increased outreach and education on Maryland's Landowner Liability and Recreational Access Law.** Private landowners are more likely to invite hunters onto their lands if they are aware of the protection from liability that this law affords.
3. **We recommend encouraging efforts by state lands managers to reduce white-tailed deer damage on public lands.** This may be done, for example, by increasing hunter access, giving more hunters more time afield, and by developing management plans directed at restoring regeneration of forest trees and other native plants**.**
4. **We recommend encouraging and facilitating more managed deer hunt programs with volunteer hunters and more programs with certified sharp shooters after regular seasons**.
5. **We recommend investigating and as appropriate implementing methods to increase donation of harvested deer for community food banks and homeless shelters.**
6. **We recommend fostering education, public awareness, and endorsement of hunting as a management tool necessary for habitat conservation, protection and control of the deer herd, and for the positive impact of hunting on State and local economies**.
7. **We recommend continuing to monitor research and development in deer biological fertility controls**. While unlikely to be effective to treat Maryland's large, free-ranging white-tailed deer population, fertility management could have a role, albeit a limited one, among various management techniques.

The Work Group also makes the following recommendation.

8. **We recommend an investigation under DNR's leadership of permitting a regulated commercial market in Maryland for wild-harvested venison, with input and open discussion from all interested stakeholders**. Input from DNR advisory committees, other stakeholders within state government, sportsmen and conservation groups, as well as non-traditional partners, may provide the way in which over-saturated bag limits per hunter (as viewed by some) can benefit the State, native habitats, and the local economy.

Recommendations to combat the threat of invasions by non-native species

The spread and the establishment of invasive species is altering and destroying Maryland's botanical heritage and natural ecosystems, as well as inflicting major and long-lasting harm to the State's agriculture, human health and economy.

1. **We recommend that resources be allocated and prioritized toward prevention, early detection and rapid response to control newly introduced or discovered invasive species before they have a chance to spread, become entrenched and are exorbitantly costly to control.** Some portion of these resources should be designated for mapping invasive species on and adjacent to high priority sites. An emergency response system

similar to the Incident Command System and an emergency pool of funds to use for immediate control work should be established.

2. **We recommend that Maryland State agencies continue to participate in the Maryland Invasive Species Council (MISC).** Although an informal organization, MISC is able to function as a coordinating body for emergency response to new invasive species, as a consensus-building organization, and as an information resource.
3. **We recommend increased support of research on and implementation of invasive species biological controls and organism release programs**. The existing program within Maryland Department of Agriculture (MDA) has been significantly cut in recent years and should be restored at least to prior levels.
4. **We recommend increased support of research on the direct and indirect impacts of invasive species on native species and ecosystems**. Research documenting and detailing the characteristics of invasive species and the harm they inflict would greatly assist in planning and funding invasive species control efforts.
5. **We recommend funding for additional ongoing assessments by the Invasive Plant Advisory Committee and for inspections by MDA under Maryland's Invasive Plants Prevention and Control Act**. Currently, funding is only available for one year for assessments of non-native plants likely to be invasive and thus subject to regulation under the law. MDA will ultimately assume responsibility for enforcement as part of its regular nursery inspection program along with the existing responsibilities of nursery inspectors. If inspections are to continue at the current frequency (already reduced from prior years), additional staff will be needed.
6. **We recommend that Maryland citizens be encouraged and provided with incentives to become involved in stewardship of lands adjoining high priority natural areas**. This is to ensure that invasive species are eradicated or reduced to a maintenance level so that they do not serve as sources for reinvasion of targeted conservation areas.
7. **We recommend establishment of a staff position for invasive species education in University of Maryland Extension Service programs including Master Gardeners**. Public awareness, especially among gardeners, is essential to lessen the spread of non-native invasive species.

Recommendations to increase the use of native plants in restoration and landscaping

The use of native plants in restoration, landscaping, and gardening should be encouraged in order to enhance biodiversity in partial compensation for the loss of natural biodiversity, and to avoid spreading non-native invasive species. This includes planting under the auspices of State agencies such as the State Highway Administration (SHA) and Maryland Department of the Environment (MDE).

1. **We recommend continuing coordination among MDE, DNR and SHA with respect to state-sponsored planting protocols where appropriate**. Those agencies recognize the value of using native plants where possible for restoration, roadsides, and other situations, and the need to avoid invasive non-native plants.

2. **We recommend supporting programs to encourage landowners to maintain gardens and landscapes for the benefit of native wildlife and to avoid invasive non-native plants.** Although there has been coordinated outreach to landowners, many members of the public remain unaware of the effects—both negative and positive—of private gardens and landscapes on our natural environment. Proactive strategies will be required to address this information gap.

3. **We recommend discussion among MDA, SHA, MDE, and DNR of the potential for an enhanced native plant and seed industry in Maryland**. Based on examples from other states and preliminary research in Maryland, there may be potential for the State, in partnership with industry, to assist in the development of an enhanced native plant and seed industry to serve Maryland customers, potentially benefitting native plant conservation and local business as well as Maryland consumers. It is understood that further development and enhancement of a Maryland-based native plant and seed industry should be industry driven and that additional dedicated funding for state agencies to providing testing, certification, licensing, and other support functions will be required for program creation and development. A possible model is included as Appendix 4.

*Figure 4. The region's largest water-willow shrublands, with endangered American Frog's-bit (*Limnobium spongia*) and other important species, in a diverse ecological community at Chapman Forest in Charles County. Photo by R H Simmons.*

Maryland's Unique Biodiversity

SUMMARY: Maryland—a small state—is home to a disproportionately large number of different native plant species and ecological communities. The current character of Maryland's natural environment is not only a tale of habitat loss through direct conversion, fragmentation and unwitting destruction by development and altered landscapes in modernity but also a tale of Maryland's historical landscape and the ebb and flow of climatic shifts in geological time.

The Wildlife and Heritage Service of Maryland's Department of Natural Resources is responsible for the identification, ranking, and protection of rare and endangered species and natural communities in Maryland. The Service currently lists 710 plant species, using a classification system that condenses a large quantity of useful information into shorthand form. Nearly 28% of Maryland's plant species are listed as rare, threatened, endangered, or extirpated. Due to historical differences in the treatment of plants and animals, plants receive less conservation protection and less funding than animals. Thus, although active conservation efforts can be successful, especially if supported by research, it is often impossible to do otherwise than simply observe and record the permanent disappearance of our botanical heritage.

Why are there so many rare plants in Maryland?

This simple question is answered by looking at the breadth of native plant[1] communities that are contained within our boundaries. Maryland's contribution to regional biodiversity is far greater than its small size would suggest. Maryland ranks among the smaller states (42/50), and when compared with our close neighbors, Pennsylvania and Virginia, we are not only smaller, we are more densely populated (U.S. Census 2010). Yet Maryland tracks some 710 taxa of rare, threatened and endangered plant species, almost as many as Pennsylvania (793), which is 4 times the size of Maryland and not far from the number tracked by Virginia (909), which is more than 3 times the size of Maryland (PA Natural Heritage Program; VA Natural Heritage Resources).

Owing to Maryland's latitude, its plant communities contain elements of both northern and southern floras. Owing to its longitude, Maryland intercepts six distinctly different ecological regions from the barrier islands along the Atlantic Coast west to the high elevations of the Allegheny Plateau. (See map in Appendix 2.)

Additional floristic complexity is due to the ebb and flow of climatic changes over geological time. Maryland was located south of the limit of glaciers during the Pleistocene Epoch (ending 11,700 years before present (ybp)) and served as a refuge for migrating plant and animal species. Many of these remain as part of our botanical heritage today. More recent climatic changes are also evidenced in our flora. During the interval ending 3200 ybp, Maryland was much warmer and much drier than it is today. Species from the midwestern prairies became part of the

[1] In the context of this Report, a 'native' plant is one that occurs naturally in the State without direct or indirect human intervention.

Maryland flora, and many of those species remain in unique natural communities today (Droege et al. 2009). Finally, the flora has been modified by centuries of habitation, not only by European and African settlers, but earlier by Native Americans who farmed, hunted and actively managed the Maryland landscape (Anderson et al. 1999, Curry 1992).

The character of Maryland's pre-settlement (pre-1634) forests and the degree of active management by fire or clearing by Native Americans is a matter of some controversy. Brush (2001) suggests that with the exception of serpentine barrens and tidal marshes the early settlers encountered a densely forested landscape. Droege et al. (2009) suggested that sites along the Patuxent River were open sandy barrens and woodlands due to intensive management by Native Americans.

Early settlers sometimes commented on the densely forested landscape (Frick et al. 1987):

> "all the low land [referring to the general landscape of the Coastal Plain] is verry woody like one continued forrest, no part clear but what is cleared by the English. An tho we are pretty closely seated, yett we cannot see our next neighborurs house for the trees."

Others characterized the landscape as being forested by large widely spaced trees (3 March 1634, A Briefe Relation of the Voyage unto Maryland, MSA SC 2221-17-5).

> "there are noe marshes or swampes about it, but solid firme ground, with great variety of woode, not choaked vp with vndershrubs, but commonly so farre distant from each other as a coach and fower horses may travale without molestation."

Colonists living in the upper bay along the Susquehanna River reported entering a great expanse of barren lands (Marye 1955, Porter 1975):

> "from the headwaters of the Patapsco, Gunpowder and Bush River west to the Monocacy there lay a vast body of barrens with no timber thereon."

These barrens as mapped (Porter 1975) extended from the Susquehanna and north of Baltimore west across Harford, Baltimore and Carroll Counties to the headwaters of the Monocacy River. So impressive was this expanse that some scholars have concluded that the barrens were responsible for delayed settlement of western Maryland (Porter 1979). They likely attributed the barrenness of the landscape to lack of fertility but it is more probable that the barrens were simply a large area burned over by Native Americans in pursuit of game (Porter 1979, Tyndall 2005). These differences between observations may lie not so much in a comprehensive characterization of the land but in the perception of peoples living in different parts of Maryland, who had no maps but a necessary awareness of their own local geography.

Estimates of the number of Native Americans historically living along the Chesapeake Bay varies greatly among scholars and ranges from 8000 to over 50,000 (Feest 1978, MSA SC 2221-17-1**)**. The actual population is less important than the impact that these peoples had upon the landscape. The presence of the "great barrens" (Marye 1955) suggests that, at least in some parts of Maryland, they managed large areas. Whatever the impact of Native American populations on the landscape, it ended abruptly as evidenced by this chilling passage in a letter dated 23 January 1698 (Letter from Hugh Jones (Calvert County, Maryland) to Benjamin Woodroffe, Principal of Gloucester Hall, Oxford, England. 23 January 1698):

> "as for our predecessors, the Indians, I cannot give you at present any further account of them than this, viszt. that whereas att the first seating of Maryland there were several

nations of Indians in the country governed by several petty Kings, now I doe not thinke that there are five hundred fightinge men of them in the province , and those are most on the Eastern Shore where they have two or three little towns" . . . . "the small pox alsoe has swept away a great many , so that now they are dwindled to almost to nothing."

Sources of complexity in Maryland flora

Summary: To understand the complexity of the Maryland flora, it helps to look at some particular kinds of examples. These are the disjunct species, the peripheral species, and species that occupy singular or regionally endemic ecosystems. A few illustrative examples are provided for each.

Disjunct plant species

Summary: "Disjunct" plant species make an important contribution to Maryland's complex flora. These are species that occur with marked geographic separation from their core species range and these populations may be ecologically divergent as well. This phenomenon is often explained by long-distance species migrations during major historical climatic shifts, and these shifts contributed to Maryland's botanical diversity in significant ways. What follows are some of the best-studied and most compelling examples.

One of the more striking Maryland disjuncts is the Nantucket shadbush (*Amelanchier nantucketensis*) (Figure 6). This species occurs discontinuously along the Atlantic Coast from Nova Scotia to Long Island, New York, and was once considered restricted to the previously glaciated regions of New England. (With rare exceptions this remains true.) In Maryland this species occurs in a relict population in the Potomac Gorge along the ancient bedrock terrace forests and outcrops of Mather Gorge. These habitats perhaps mimicked the rocky, barren habitats of New England upon retreat of the ice sheets and likely served as a refuge during the last glacial maximum. Whatever the mechanistic details of the species arrival in Maryland, the presence of this species is fascinating not only to the bio-geographer but to anyone having the imagination to conjure up a landscape containing mammoths and bison.

This general pattern is reflected in the distribution of the federally endangered swamp pink (*Helonias bullata*) (Figure 6). This plant occurs along the Fall Line (where Piedmont gives way to the Coastal Plain) in Maryland in a series of seepage swamps (with surface flow of spring-fed water). This population is now widely disjunct from the most genetically diverse populations located in the Southern Appalachians (Godt et al. 1995, Hamrick and Godt 1996).

Figure 6. Three of Maryland's rare disjunct species. From left to right: Nantucket shadbush, Amelanchier nantucketensis, *Photo by Christopher Frye; Showy goldenrod,* Solidago speciosa, *Photo by Kerry Wixted; swamp pink,* Helonias bullata, *Photo by Kerry Wixted.*

One of the most influential climatic events on Maryland's flora was the pronounced warming period called the Hypsothermal Interval during which some midwestern plant species expanded their ranges eastward. The average temperature during this interval may have been up to 5° F warmer than today and precipitation levels may have dropped by as much as 25%. Consequently, a number of species more frequently associated with midwestern prairies now occur in Maryland in disjunct populations. An example is pale false foxglove (*Agalinis skinneriana*), which occurs in Maryland in small populations in sandy barrens of the Coastal Plain. Pettingill and Neel (2008) found that the plants occurring in Dorchester County on Maryland's Eastern Shore were genetic sisters to a population of plants from Missouri. The core range of *A. skinneriana* is in the central United States.

The Maryland flora also contains populations of midwestern species that are large enough or extend over such a significant geographic area as to be considered a separate part of the species range. For example, Virginia nailwort (*Paronychia virginica*) occurs in disparate zones, one centered around the Potomac River (MD, VA, WV), one in northern Georgia and Alabama and one zone around Missouri and Arkansas (NatureServe 2013).

The final example, showy goldenrod (*Solidago speciosa*) (Figure 6) relates to modification of the environment by Native Americans and is an example of a within-state disjunct. This species was long-thought to be restricted to southern Maryland in prairie-like habitats persisting in artificially maintained right of ways. However, McAvoy and Harrison (2012) discovered the species over Native American shell-middens on the Eastern Shore. This finding is fascinating because the shell-middens were manmade, created by dumping oyster shell in the same locations over thousands of years—time enough for these habitats to intercept and retain elements of an advancing western flora.

Figure 7. Canada yew, Taxus canadensis*, a rare and threatened peripheral species that currently exists only in locations inaccessible to white-tailed deer. Photo by Peter Stango.*

Peripheral plant species

Summary: Maryland's latitude places it at the southern end of northeastern ecosystems and the northern end of southeastern ecosystems. Whether a species hails from the north or the south, the Maryland flora is replete with examples of species at or near their natural range limits, in what biologists call "peripheral" populations.

The famous English naturalist John Ray (1627-1705) illustrated a new world plant species delivered to him from the Maryland colony in 1688. The species was Spanish moss (*Tillandsia usneoides*) and within the Maryland catalogue Ray also discusses Galax (*Galax urceolata*) (Brown et al. 1987). According to Brown et al. (1987),

> "apparently the colonial naturalists collected only on the coastal plain of Maryland. . . [Most importantly,] as the geographic attributions accompanying their specimens always refer to Maryland, we can only conclude that the species known today only from southeastern Virginia must have occurred in Maryland in the past." (p 248)

These examples are extraordinary not only because neither species has been seen in Maryland for centuries but also because both of these species very likely reached their northern range limits in Maryland.

The mountains of Garrett County provide excellent examples of northern species that occur in peripheral populations. Some of the more striking examples are buckbean (*Menyanthes trifoliata*), and Canada yew (*Taxus canadensis*) (Figure 7). Both of these species are restricted to Garrett County near the southern ends of their natural ranges. Maryland populations of buckbean and Canada yew form part of these species discontinuous southern ranges. The Coastal Plain contains multiple examples of species reaching both their southern and northern range limits. For example, northern golden heather (*Hudsonia ericoides*) a common low shrub ranging from Newfoundland through New England, is restricted to southern Maryland at its southern range limit (Weakley 2010 reports a single disjunct location in South Carolina). Pondspice (*Litsea aestivalis*) (Figure 8), a rare southeastern coastal shrub, is found at a single station on the Eastern Shore at its northern range limit. A final example, sourwood (*Oxydendrum arboreum*), may reflect two different periods of migration. A characteristic and common subcanopy tree south of Maryland, the few, scattered Maryland records represent remnant populations near the northern range limit.

Figure 8. Pondspice, Litsea aestivalis, *a rare southeastern coastal shrub is found at a single station on the Eastern Shore at its northern range limit. Photo by Christopher Frye.*

Singular plant communities

Summary: Maryland contains valuable "singular" plant communities, which are occupied by a number of very rare plant species, among which may be peripheral and disjunct plant species. Soldiers Delight Natural Environmental Area is an outstanding example.

Of the "Great Barrens" of Maryland (Marye 1955) that at one time covered approximately 250,000 acres (Tyndall 2005), a remnant of about 1000 acres remains at Soldier's Delight Natural Environmental Area (SD). SD is a landscape of natural grasslands and oak savanna over the largest outcrop of serpentine in the eastern United States (Tyndall 2005). Now heavily fragmented and greatly altered by fire suppression and the resulting invasion by Virginia pine (*Pinus virginiana*), it remains a singular plant community occupied by a number of very rare plant species. Among these species are excellent examples of peripheral and disjunct plant species.

For example, SD holds the nation's largest population of the federally endangered sandplains gerardia (*Agalinis acuta*). This species is distributed in a series of disjunct populations from the District of Columbia (historical) and Maryland north to Massachusetts. Several sedge species are nearly restricted to the SD grasslands. Mead's sedge (*Carex meadii*) occurs at SD in the state's largest and most viable population and Richardson's sedge (*Carex richardsonii*) is entirely restricted to SD. Both species are components of midwestern prairies and occur in Maryland as populations disjunct from their core ranges. Additionally, SD contains the largest population of interior sedge (*Carex interior*), a peripheral species (from the north) that additionally represents an interesting ecological shift in the species habitat. *C. interior* occurs as a very common wetland plant in the northeastern United States but has highly restricted habitat in Maryland occurring only in sites with ultramafic (high nutrient content of the soils) substrates like serpentine and diabase. This latter situation is illustrative of the concept behind state ranks, which is to capture as much of the adaptive genetic variation in species as possible, thus potentially allowing the species to adapt to changes in climate or other anthropogenic changes in habitat.

The character of the soils, particularly those soils rich in calcium, gives rise to a number of diverse plant communities. For example, limestone bluffs and rich forests in the limestone region of Maryland (essentially the northern extension of the Blue Ridge in Washington County) are unparalleled in overall species richness. Engelhardt (2004) found over 110 species of vascular plants in a single 20 x 50 meter plot along Antietam Creek in Washington County. Many of the

rare plants at this location are obligate calciphiles (calcium-loving). For example, Hitchcock's sedge (*Carex hitchcockiana*) occurs in large populations along with a profusion of wildflowers. Calcium-bearing soils in dry, exposed habitats such as cliffs or steep slopes also give rise to unique plant communities. For example, arbor-vitae (*Thuja occidentalis*), a nearly ubiquitous species of bogs and wetlands in the northeastern United States, is highly restricted to limestone bluffs and outcrops, particularly along the Potomac River. The globally rare tall larkspur (*Delphinium exaltatum*) occurs in limestone woodlands along with a variety of habitat-restricted species including the running serviceberry (*Amelanchier humilis*), which reaches its southern range limit in Maryland and adjacent West Virginia.

Some plant communities have been entirely extirpated, not during pre-colonial times but recently. These "historical" plant communities may only be reconstructed through the cataloging of museum specimens. For example, during a period ranging from approximately 1888 to 1921 a number of species were collected in the vicinity of Mountain Lake Park in the southern Garrett County. Amongst these species were Kalm's brome grass (*Bromus kalmii*) and fringed brome (*Bromus ciliatus*). Neither of these species has been seen since 1921. In association with these collections we find multiple collections of the state-endangered Indian paint brush (*Castilleja coccinea*), along with a group of species now considered extirpated including spotted joe-pyeweed (*Eutrochium maculatum*), American lovage (*Ligusticum canadense*) and another striking disjunct from the Midwest, downy gentian (*Gentiana puberula*). Apparently, this was once the site of a prairie-like grassland and calcium-rich wetland—now extirpated by the construction of a reservoir and use of the area as a landfill.

Regionally endemic plant communities

Summary: An "endemic" native plant community is one that occurs in only one location on earth. Several of these are known in Maryland. In all likelihood, others have been lost without ever having been discovered.

Of the native plant communities endemic to the region, the intertidal habitats (occurring along the shorelines between low and high tides) along the Chesapeake Bay and its tidal tributaries comprise a distinctive set of globally rare and near-endemic species. Seaside alder (*Alnus maritima* ssp. *maritima*) is a wetland shrub restricted to tidal rivers on the Eastern Shore and Delaware. Two other subspecies have disjunct populations occurring in Georgia (ssp. *georgiensis*) and Oklahoma (ssp. *oklahomensis*). This odd distribution is thought to be the result of range retraction during a glacial epoch leaving stranded populations in disparate locations that have now diverged genetically and ecologically (Schrader and Graves 2004). Another globally rare species is the regional endemic Maryland bur-marigold (*Bidens bidentoides*) that occurs in the upper Chesapeake Bay, Delaware Bay and few stations in New Jersey and New York. Maryland has the lead responsibility for ranking this species as Maryland populations comprise the bulk of individuals within its narrow range. Also in intertidal habitats lives federally threatened sensitive joint-vetch (*Aeshynomene virginica*), which occurs from New Jersey south to North Carolina but is currently extant in only 20 locations (NatureServe 2013). Additionally, the Chesapeake Bay contains many relatively common species that occur over vast areas in freshwater, brackish water and saltwater marshes.

On the Eastern Shore of Maryland occur a group of natural wetlands called Delmarva Bays. These are shallow, seasonally flooded, freshwater wetlands that are generally small (< 1 acre) but

numerous, with an estimated 1500-2500 ponds present on the Delmarva Peninsula (McAvoy and Bowman 2002). The plants of these bays are adapted to a seasonal drawdown of the groundwater with extreme variation in dominant species. Early in the spring when the bays are full they appear like any other pond with emergent and floating vegetation. The same bay may appear to be grassland in late summer and fall with a completely different set of dominant species. The species composition is zonal, from open grassy swales dominated by herbaceous species near the center of the pond to forested wetlands around their perimeters. According to McAvoy and Bowman (2002) Delmarva Bays harbor 45 rare and uncommon species, eight globally rare species and the federally endangered Canby's dropwort (*Oxypolis canbyi*); the latter occurs in a single pond in Queen Anne's County. One of the more intriguing globally rare plants is the diminutive Harper's fimbristylis (*Fimbristylis perpusilla*). This is a tiny, inconspicuous grass-like plant growing only a few inches tall that is restricted to the very center (the lowest elevation) of the ponds. It may grow thickly in the exposed muddy soil—but only in those years where the ponds are completely dry. The total habitat area for this species may be less than a half-acre with each pond contributing a few square feet! This plant ranges from Maryland south to Georgia, a typical distribution for plants of Delmarva Bays (McAvoy and Bowman 2002). On the other end of the spectrum is rose coreopsis (*Coreopsis rosea*) (Figure 9), a lovely aster-like plant that is restricted to only two ponds on the Eastern Shore.

Figure 9. Two species found in regionally endemic plant communities. (left) Rare and threatened Kate's-mountain clover, Trifolium virginicum*, endemic to shale barrens. Photo by Christopher Frye; (right) Rare and endangered Rose coreopsis,* Coreopsis rosea*, known from two Delmarva Bays on the Eastern Shore, endemic to Bay wetlands. Photo by Wesley Knapp.*

At the other extreme, Maryland contains part of the biodiversity zone known as the Mid-Appalachian Shale Barrens. These extremely dry and sun-baked barrens and woodlands contain 18 species found nowhere outside of the narrow Appalachian range from southwestern Pennsylvania, Maryland, western Virginia and adjacent West Virginia (Keener 1983). The flagship species of the shale barrens is a native clover called Kate's-mountain clover (*Trifolium virginicum*) (Figure 9). Maryland contains almost 100 populations of this species in a narrow ~18 kilometer-wide zone in Allegany and Washington Counties. The plants that live in these harsh habitats are obligate sun-lovers and are intolerant of shade. Kate's-mountain clover grows in exposed beds of shale with little to no soil development. Other species endemic to the shale barrens are the aptly-named shale barren goldenrod (*Solidago harrissii*), shale barren ragwort (*Packera antennariifolia*) and shale barren primrose (*Oenothera argillicola*). In the stream

valleys where nutrients accumulate and soil moisture is less limiting, this narrow region of Maryland contains some of the most diverse displays of native wildflowers in the state.

Continuing discovery

Summary: A surprising number of plant species are still being discovered. Although it is impossible to prove, it is a certainty that we have lost species from the State that we never knew and will never know existed. Given the threats outlined in this Report it is more critical than ever to find and protect the rare flora of the State.

In 2011 Knapp et al. reported fifteen new native additions or rediscoveries to the flora of Maryland. In 2012 and 2013 an additional 9 species have been documented. Nearly all of these discoveries are or will be treated as rare, threatened or endangered. Among these discoveries are species in groups one would think have been thoroughly explored such as orchids and tree species. Numerous recent discoveries also mark range extensions that would also be considered noteworthy from a conservation standpoint.

*Figure 10. Water Pygmyweed (*Crassula aquatica*), presumed extirpated, recently rediscovered at Allen's Fresh Natural Area in Charles County, and now considered rare and endangered. Photo by Wesley Knapp.*

Conservation of Maryland's Rare, Threatened and Endangered Plants

Regulatory authority, responsibility and resources for native plant conservation in Maryland

Summary: For historical reasons, legal protection for plants is different from that for animals. In Maryland, the Nongame and Endangered Species Conservation Act defines criteria for listing for both plant and animal species in need of conservation attention. The lead agency with this responsibility is the Wildlife and Heritage Service within DNR, which maintains a database of natural areas and occurrences of rare, threatened and endangered plant and animal species. This database is aligned with an international network (the Natural Heritage Network). Funding for conservation work on plants is largely limited to one source, the Chesapeake Bay and Endangered Species Fund, generated from state tax check-off revenue.

Because of its origins in the Teddy Roosevelt era and the nature of formative initiatives such as the Migratory Bird Treaty Act, most conservation policy and law deals with animals rather than plants. Under the North American model for conservation, various units of government were established under the Department of the Interior in order to address specific priorities: The Forest Service would provide healthy forests for the production of timber, the Park Service would take care of the parks, and the U.S. Fish and Wildlife Service would deal with fish and wildlife. Lands not managed by one of these three agencies would be under the purview of the Bureaus of Land Management and Reclamation.

When the Federal Endangered Species Act became law in 1973, protection was provided to animals as populations and individuals, but not to the plant communities that comprised their habitat. Since the Act's inception, plants have been added to the federal endangered species list, but with lower standards of protection. Today most federal funding for unique species is specifically designated for animals or even for "birds and mammals" only.

Similarly, in Maryland's version of the Endangered Species Act, while wildlife are well provided with protections (from some activities), plants are effectively left to the discretion of a property owner who may destroy them under most circumstances if that is his wish. Federal and state wildlife laws in the United States have their origins in old English common law where the King and Parliament owned the wild animals and prescribed the ways that ordinary citizens could harvest them on all lands, public or private. By contrast, plants were considered to be a part of the land on which they grew and thus plants on private lands were treated as the owner's private property.

The primary State law (enacted in 1975) that allows and governs the listing of endangered species is the Nongame and Endangered Species Conservation Act (Annotated Code of Maryland 10-2A-01). The Act is supported by regulations (Code of Maryland Regulations 08.03.08) that define listing criteria for endangered, threatened and endangered extirpated species, establishes the purpose and intent of collecting permits and lists prohibited activities. Again, plants on private lands are viewed as the owner's property. In contrast, on public lands,

State agencies tasked with management of those properties are required to take into account the presence of threatened and endangered plant species during project reviews.

Maryland land planning efforts have historically accounted for sites containing protected species relatively late in the planning process, as road designs, industrial development, or subdivision plans were reviewed. The news of the presence of unique habitats or rare species generally has been an unpleasant surprise for permit applicants. Recent efforts by Maryland state government to highlight these areas, notably the 'Green Infrastructure" model, have made the locations of many unique natural communities available to county planning and zoning departments. In some areas, this information is being incorporated into local master plans, but county use of the data is not uniform.

The threats to Maryland's botanical heritage, and therefore to its wildlife heritage, are not news. Recognizing this, the General Assembly and the Governor have assigned to state agencies numerous responsibilities to manage, control, and alleviate the forces that threaten our state's biodiversity.

Since 1979, the **Wildlife and Heritage Service** (the "Service") within DNR has been the lead state agency responsible for the identification, ranking, protection and management of rare and endangered species and natural communities in Maryland.[2] The Service seeks to identify and sustain populations of rare plants and animals through the maintenance of healthy natural ecosystems. The Service also reviews proposed development projects for potentially harmful effects on rare species. The Service maintains a database of natural areas and occurrences of rare, threatened and endangered plant and animal species. This database is aligned with an international network (the Natural Heritage Network) that tracks and monitors species using identical methodologies, nomenclature, and units of measure across all fifty states, Canada and Latin America. In Maryland, the Service has documented approximately 720 sites that support unique habitat for either plants or animals. Moreover, habitats that support rare animals without the support of specialized plant communities are a small component of these sites. Plant communities are generally the baseline fabric of natural communities that support both rare plants and animals.

The Service provides recommendations for the conservation of rare plant species and plant communities through its coordination and advisory role with other agencies in environmental review. Maryland Department of the Environment (MDE) and other regulatory agencies and programs provide some opportunity for rare plant and plant community conservation, though plant conservation is one of numerous considerations. The Tidal Wetlands, Nontidal Wetlands and Waterway Construction statutes and regulations, implemented by MDE, include such considerations and often require project re-design to address concerns related to protection of designated plants which are state endangered or threatened. MDE screens all project applications for the presence of rare species and coordinates with DNR on protective measures to balance these concerns with goals of applicants. Nontidal Wetland regulations also designate certain wetlands as "Nontidal Wetlands of Special State Concern," which include wetlands of unique natural community types and rare plant species. These wetlands are surrounded by a regulated 100-foot buffer and are subject to more stringent review requirements than other nontidal wetlands.

[2] Direct responsibility for these functions lies with the Maryland Natural Heritage Program, a component of the Wildlife and Heritage Service.

It is critical to understand that funds for work on rare plants are largely limited to one source, the Chesapeake Bay and Endangered Species Fund, generated from state tax check-off revenues, with much smaller contributions from federal sources for federally endangered or threatened species only.

Over the years, the resources available for conservation efforts by state agencies have continually dwindled to the point where tasks that Maryland citizens would expect to be done cannot be done. Insufficient resources are available for the most basic of conservation tasks: surveying plant populations to detect and assess changes, threats and long-term trends; data collection and inventory; monitoring and managing existing plant conservation efforts; and outreach to landowners to encourage conservation on private land. This results in insufficient protection status for many plant species and populations, and inadequate protection for those species identified as in need of protection.

In some cases, the Wildlife and Heritage Service may work with other agencies within DNR, with private organizations, or with other federal funding sources to purchase properties supporting natural communities, restore natural communities that support rare plants and animals, or to fund other projects involving both rare plants and animals. By focusing energies on those plants, animals and natural areas that are most in danger of disappearing, the Service attempts to ensure that these essential elements of Maryland's diverse biological heritage do not vanish from our landscape.

Figure 11. Barrens Strawberry, Waldstenia fragarioides *(foreground, yellow flowers) growing with rare and threatened Senega Snakeroot,* Polygala senega *(background, white flowers) in Green Ridge State Forest, Allegany County. Photo by Christopher Frye.*

What it means for a plant species to be classified rare, threatened or endangered

Summary: The list of Maryland's rare, threatened and endangered (abbreviated RTE) species reflects Maryland's unique geographic position in the United States. The current RTE list comprises some 710 species, subspecies and varieties. In order to quickly relate information on the level of rarity and endangerment of species, the RTE list uses a set of shorthand metrics. These metrics communicate two basic pieces of information: (1) the conservation rank, a generalized measure of rarity; and (2) conservation status, a declaration of legal status through the familiar terms, threatened and endangered.

Conservation Ranks and Conservation Status

Conservation ranks are arranged along a simple numerical scale (1-5) with the lower numbers reflecting increasing rarity. Conservation ranks also present geographic information about rarity. State ranks (S ranks) communicate the rarity of the species in the State whereas global ranks (G ranks) communicate the rarity of the species throughout its range (although the term "global" is used, most species are far from being globally distributed). The rank of a species is determined through analyses of population number, size, viability, threats and trends among other things. The final metric, a combination of the numeric index (1-5) and the geographic identifier (G or S) distills this large amount of information into a single metric. By analogy, sports statistics don't relate everything about a player, but they provide an index so that one can visualize how a particular player compares with others. State ranks for many species are modified annually, and status is reviewed every 2-5 years or as needed.

Thus, for a particular plant species that has a global rank of G1 and a state rank of S1 the species is not only rare within Maryland but also rare within its entire range. Similarly, a plant species with ranks of G5 and S5 relate that the plant is common in Maryland and demonstrably secure in its global range. Definitions of conservation ranks are presented in Table 1. All states (and Canadian provinces) use the same ranking system and format. This allows comparisons across the political and geographic landscape and it is one of the most powerful aspects of the network of State Natural Heritage Programs.

Conservation status presents a simple hierarchy of endangerment in three, mostly familiar, categories: threatened (the lowest status), endangered (the highest status), and endangered-extirpated (a category unique to Maryland). Definitions of conservation statuses are presented in Table 2. All species listed as threatened and endangered at the federal level are also listed by individual states where the species occurs. This provides a segue into the statistics of the current Maryland RTE plant list. (For a more detailed explanation of the operation and utility of the RTE Plant List, see Appendix 3.)

Table 1. Definitions of Global (G) and State (S) Conservation Ranks. The conservation rank of a species is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global and S = Subnational/State or Province).

Rank	Definition
GX or SX	**Presumed Extirpated**—Species believed to be extirpated from the jurisdiction (i.e., nation, or state/province). Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
GH or SH	**Possibly Extirpated**—Known from only historical records but still some hope of rediscovery. There is evidence that the species may no longer be present in the jurisdiction, but not enough to state this with certainty..
G1 or S1	**Highly Rare and Critically Imperiled**—At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors. Typically occurring in fewer than 5 populations.
G2 or S2	**Rare and Imperiled**—At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors. Typically occurring in 6 to 20 populations.
G3 or S3	**Rare to Uncommon and Vulnerable**—At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors. Typically occurring in 21-80 populations.
G4 or S4	**Apparently Secure**—At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5 or S5	**Secure—**At very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.

Table 2. Definitions of State and Federal Status.

State Status	Definition
Endangered (E)	A species whose continued existence as a viable component of the State's flora is determined to be in jeopardy.
Threatened (T)	A species that appears likely within the foreseeable future to become endangered in the State.
Endangered-Extirpated (X)	A species that was once a viable component of the flora of the State but for which no naturally occurring populations are known to exist.
Federal Status	**Definition**
Endangered (LE)	Listed as endangered under the federal Endangered Species Act; in danger of extinction throughout all or a significant portion of their range.
Threatened (LT)	Listed as threatened under the federal Endangered Species Act; likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

What can be learned from lists of rare, threatened and endangered plants

SUMMARY: Nearly 28% of Maryland's flora—710 species—are rare, threatened, endangered or extirpated (RTE). Of these, 343 are classified as rare, meaning that they occur in fewer than 5 populations, and 48 are considered historical or extirpated. DNR's Wildlife and Heritage Service is solely responsible for the listing, management and recovery of all RTE species. This is a significant challenge, especially considering that these species are scattered across Maryland in hundreds of individual sites and populations.

A breakdown of the Maryland flora according to both rank and status is presented in Figure 12. From this figure we see that the largest wedge in the pie presents the good news: 72% of the Maryland flora isn't rare. **The bad news is that nearly 28% of the Maryland flora is rare, threatened, endangered, or endangered-extirpated.**

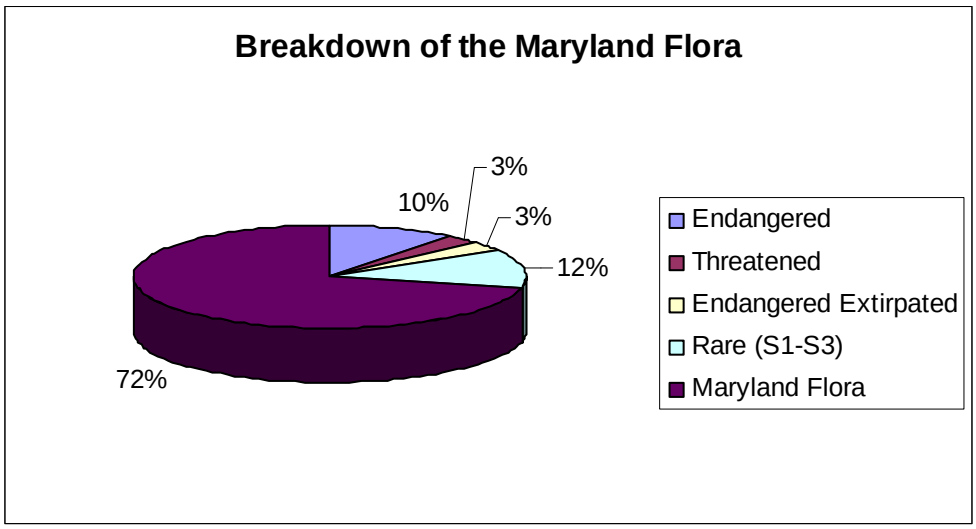

Figure 12. Breakdown of the Maryland Flora by Rank and Status. (Based upon an estimate of 2500 vascular plants in the Flora).

Twenty-eight percent represents 710 species. This number is striking. Consider that DNR's Wildlife and Heritage Service is solely responsible for the listing, management and recovery of all RTE species. The challenges in dealing with so many species become evident. Further, these species are scattered across Maryland in hundreds of individual sites and populations, presenting logistical challenges for the small staff of the Service's Natural Heritage Program.

Figure 13 presents the breakdown of ranks for Maryland's 710 rare plants. The largest category is S1 (47%), meaning that about 343 species occur in fewer than 5 populations! Roughly 17% of the rare plants occur in fewer than 21 populations (S2) and 22% are considered vulnerable (S3). An astounding 14% of the rare plants are considered either historical (SH, 13%) or are considered extirpated (SX, 1%).

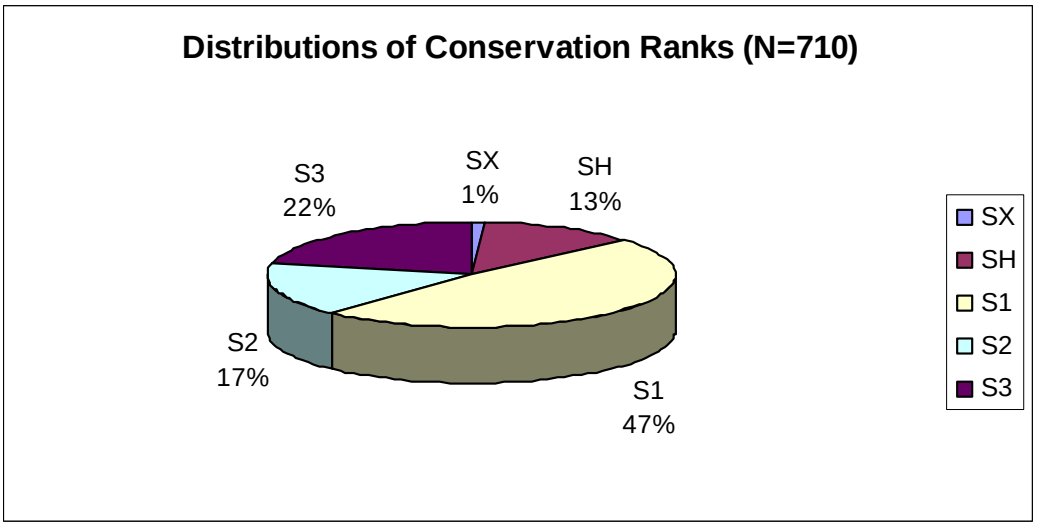

Figure13. Distribution of Conservation Ranks for Maryland's Rare Plants.

To illustrate some of the logistical and management challenges consider the following example of an S1 species:

> *Castilleja coccinea* (L.) Spreng. Indian-paintbrush G5 S1 Endangered
> Orobanchaceae (Broomrape Family)
> Conservation note: Critically endangered due to habitat loss. Reduced to small, isolated fragments of habitat.
> Allegheny Plateau, Piedmont, Ridge and Valley* (physiographic areas): mafic fens, meadows, and occasionally roadsides (Carroll, Cecil*, Frederick*, Garrett).

Indian-paintbrush is listed as endangered because of habitat loss and from this example we understand that each population is likely small, occurring in small and isolated fragments of prairie-like habitat from Carroll County west to Garrett County (extant) but occurred historically (indicated by asterisks) from Cecil and Frederick Counties. Management at these locations requires many activities including managed grazing, invasive species control, and annual mowing as well as general monitoring of the populations (stem counts, flowering and seed production, etc.). For the present time, the Wildlife and Heritage Service is rarely able to undertake such activities due to lack of resources. Rather, the Service goes through a process of triage, taking those species in critical need first.

The additional bad news is that some species will always be endangered or threatened, that is, recovery is not possible because either we do not understand the reasons for population declines (that may be related to ecosystem function) or the habitat is so specific and so reduced that the population occurs only at one or a few stations.

This is a dismal assessment but it is made from a particular frame of reference; chiefly that specific plant conservation projects are difficult if not impossible to fund under the prevailing wildlife-centric budget. Thus, plant conservation proceeds with individual efforts, but with a botanically oriented staff of 6, most of whom perform many other functions. Efforts dedicated to plant conservation are necessarily limited.

However, there are species for which conservation efforts have proven not only efficacious but have resulted in population growth. For example, restoration of serpentine grassland and savanna at Soldier's Delight has resulted in a stable population of the federally endangered sandplain

Figure 14. Rare and endangered sandplain gerardia, Agalinis acuta, *is a singular disjunct species found at Soldiers Delight Natural Environmental Area. Conservation efforts have been successful, resulting in population growth. Photo by Wayne Tyndall.*

gerardia (*Agalinis acuta*) that is the largest population in the United States. Restoration of bog turtle wetlands in the Maryland Piedmont has stabilized an otherwise declining population of Canada burnet (*Sanguisorba canadensis*). Woody plant management at an inland sand ridge site has resulted in the State's largest population of sundial lupine (*Lupinus perennis*) as well as the largest, most viable population of a globally rare butterfly, the Frosted Elfin (*Calophyrs irus*), an obligate associate of lupine (host plant).

Conclusions concerning ongoing conservation of Maryland's rare, threatened and endangered plants

Summary: The situation is dire for many of Maryland's plant species. At current funding and staffing levels, the Wildlife and Heritage Service struggles to accomplish the most basic tasks of monitoring and record keeping, and is able only occasionally to conduct conservation projects in the field. Moreover, the infrastructure needed to support plant conservation—herbaria (collections of preserved plant specimens), and botanical/ecological research—is crumbling. The Work Group's recommendations do not aspire to the ideal, but attempt to take the reality of budget limitations into consideration.

We conclude that at the current level of support we will be unable to halt the movement of many species from rare to threatened to endangered simply for lack of adequate funding—a point made clear almost two decades ago by Schemske et al. (1994) and more recently by Stein and Gravuer (2008). These losses will occur as a result of increasing urbanization, resulting in direct habitat conversion (immediate loss due to development), but also as a result of habitat fragmentation, competition and displacement by invasive species, and herbivory by white-tailed deer (longer-term losses). Other forms of loss, particularly the losses of individual populations where already rare species become numerically rarer, will also occur. Clearly loss of individual populations will occur due to direct development pressures but also and significantly because population-level processes of reproduction and recruitment will be altered. Detecting and mitigating these losses requires the kinds of monitoring and management that we usually are not able to perform.

In addition, the Work Group is deeply concerned about two extrinsic factors unrelated to actual species and population losses but nevertheless impacting our ability to perform conservation work. The first factor regards the disappearance of biodiversity collections (herbaria). Natural history collections have long been indispensable resources for studies of biodiversity, and the need to maintain them has recently taken on greater urgency. These collections offer a unique

perspective, providing data over a long time span. They are essential for the study of habitat loss and fragmentation, biological invasions, and the consequences of global climate change. Maryland's biodiversity collections that allow long-term analyses of botanical trends (including the DNA archived in those collections) seem to be perpetually under threat of dismantlement. Where collections have been maintained, they are maintained on a starvation diet of funding allowing little other than general maintenance. Much has been written about the values of those collections (Suarez and Tsutsui 2004).

The second factor regards the attrition of botanical capacity in our state universities and resource management agencies (Kramer et al. 2010). The outcome likely will be that new generations of conservation biologists are discouraged from entering botany because of the lack of research funding. Certainly, without specific plant conservation funds, DNR is unable to support undergraduate and graduate research—no matter how integral the research questions might be to management or recovery of the species. Despite these limitations, DNR botanists work closely and collaboratively with faculty and staff of Maryland universities but those relationships and the work performed are often based upon a spirit of volunteerism and on shoestring budgets.

Declining revenues in State budgets appear likely to continue. Our recommendations reflect what we believe can be accomplished with existing resources, as well as with modestly enhanced funding or staff support. We recommend a thorough revaluation of conservation priorities. Those priorities and our overall strategies are presented in following sections.

The Rapid Loss of Maryland's Native Plants and the Wildlife that Depends on Them

Challenge: Habitat loss and fragmentation

SUMMARY: There is widespread agreement that the loss of biodiversity on local, regional and global scales is driven by habitat loss and fragmentation due to development for commercial, agricultural, residential and industrial uses. The impact is not only on rare and uncommon species but also on what might be regarded as "ordinary" natural areas: those with relatively common plant and animal communities that still have great value, and that are rapidly becoming less common. Alleviating these effects implicates policy decisions that are, for the most part, beyond the scope of this Report. The Work Group supports ongoing efforts in Maryland to concentrate development in suitable areas, so as to protect plant and animal communities and to preserve natural plant and wildlife corridors.

The scope and pace of development in Maryland

Although landscape changes have always been part of the natural process, the colonization of Maryland in 1634 and subsequent settlements by European and African immigrants drastically impacted the ecological balance due to the rapid pace and scope of these activities (Maryland DNR 2005). Forests were cleared to make way for farms and trees were felled to build cabins, furniture, and ships, and to provide fuel for a rapidly increasing population. Wetlands were ditched to enhance agricultural production and the natural creation of wetlands was seriously impacted by the dramatic harvest of beavers for the fur trade. Competition and impacts from non-native species also began, when colonists brought plants and animals from their homelands. With the industrial revolution came pollution that further degraded Maryland's streams and waterways. The remaining forests were logged to produce lumber and charcoal, and coal was extracted to power factories and railroads. Canals were dug for commerce and transportation and rivers were dammed for water supplies, flood control, and power plants. Channels were dredged through the estuaries to enhance shipping ports. Highways were cut through mountains, and road networks fragmented natural habitats.

Many of these same alterations to our environment have continued through modern times, exacerbated by Maryland's ever-growing human population. Maryland is the fifth-most densely populated state in the nation. Its 2010 population of 5.8 million people lives on an average of just over one acre of land per person. Twenty-seven percent of the 6.2 million acres of land in the State has been developed, and much of the undeveloped land is fragmented to the point where natural habitats cannot persist. More than 60% of the developed land—roughly 1 million acres—was developed since 1973, as illustrated below (Figure 15). **In other words, it took three centuries to develop the first 650,000 acres of land in Maryland and 40 years to develop the next million**. By 1993, both the state's forests and wetlands had been reduced by half (Weber 2003).

An assessment of development patterns in the state from 1997 to 2000 determined that western Maryland suffered the highest losses (over 8,600 acres) of forests that were formerly large, contiguous forest blocks. Furthermore, an analysis of the risk of forest loss based on these development patterns found that the most likely counties to be further developed (to the detriment of these large forest blocks) are Cecil, Garrett, Howard, Montgomery, St. Mary's and Washington (Weber 2004).

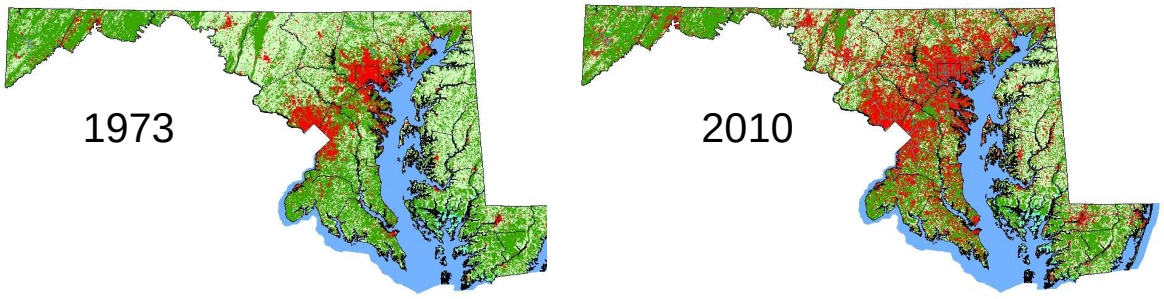

Figure 15. Land cover maps from 1973 (left) and 2010 (right) show a dramatic increase in developed areas (red sections) and loss of agricultural and forested areas (green) over the last 40 years. Source: Maryland Department of Planning.

The decline of single family home construction during the national recession of 2007-2009 has recently changed, with new home construction on the rise for the third year in a row. The largest component of new residential development is single-family home construction. During 2012, the building of 9,232 new single family homes was authorized—the highest number of single family homes since 2007 and an increase of 10% over the number of houses authorized in 2011.

Residential development has generally expanded outward in three waves: first to close-in suburbs bordering Baltimore and Washington, then in the outer ring of suburbs lining the beltways and radial highways, and most recently in far-flung exurbs in portions of Western Maryland, Southern Maryland, and the Eastern Shore. A similar pattern has occurred around smaller cities at a smaller scale, such as Salisbury, Hagerstown, Bel Air, LaPlata and Frederick. These regional trends continued in new housing construction in 2012.

Since the late 1960s, the average single-family home in Maryland has been built on a larger lot, from about one-third of an acre in the 1940s to about two-thirds of an acre today, while the number of people living in each housing unit has decreased. This has translated into more homes that house fewer people and consume more land. If trends continue, by 2035, the Maryland Department of Planning estimates that 491,000 housing units will be added, an additional 404,000 acres of land will be developed, and Maryland will lose an additional 226,000 acres of farmland and 176,000 acres of forest. More than 87 percent of these acres will be converted to low or very-low density residential development.

Residential development has and will continue to influence native plant habitats through direct habitat loss, fragmentation, and loss of natural processes.

*Figure 16. Three common spring wildflowers whose numbers are diminishing. Left to right: Trout lily, (*Erythronium americanum*), Wild blue phlox (*Phlox divaricata*), and Golden ragwort (*Packera aurea*). Photos by Janice Browne, janicebrowne.com.*

The impact of development on native plants

The apparent emphasis on rare, threatened and endangered species in this Report should not be taken to mean that these are our only conservation concern. The disappearance of habitat formerly occupied by relatively common species is also serious. These "ordinary" natural areas provide important services for humans and for wildlife, and they too are under stress, with common and uncommon species making their way to vulnerability and on to rarity. A number of species considered common by the authors of *Herbaceous Plants of Maryland* (Brown and Brown 1984), are increasingly hard to find. To take one example, Brown and Brown describe pink lady's slipper, *Cypripedium acaule*, as "common throughout" the State. While not (yet) rare, this plant can no longer be considered common throughout the State.

Of the 710 plant species considered rare, threatened or endangered in Maryland, 100 are considered historic (not having been seen in 20 or more years) or extirpated (lost with virtually no chance of rediscovery). Most of those disappeared because of habitat alteration or destruction. Often a plant now considered historic or extirpated was known from a single (or very few) high quality sites that became degraded or destroyed outright by development.

One illustrative example of such loss is the story of the golden colicroot (*Aletris aurea*), now considered historic/extirpated. This species was known from a single Maryland location in a globally rare habitat type: fall-line gravel terrace bogs. Located between Washington D.C. and Baltimore, these irreplaceable habitats are small but highly diverse wetlands that support numerous rare species of plants and animals. A key component of this habitat type is fire. Without fire (or similar habitat management) these habitats convert to shrub-dominated or forested wetlands. The rare species that occupy this globally rare habitat require an open condition and are not present when woody plants dominate. With fire excluded from the landscape and given the development pressure in the Baltimore-Washington corridor, many of these habitats and the species associated with them have been lost.

Even in rural portions of the State, single high-quality sites have been lost that supported numerous species now considered historic/extirpated. This is the case with the downy gentian

(*Gentiana puberulenta*), which was lost with the construction of a reservoir. Sometimes a species such as one-sided pyrola (*Orthila secunda*), which was known from nearly a dozen locations in multiple counties, is lost due to development pressure and most likely also from high levels of deer herbivory.

The loss of fire in our landscape—an unavoidable result of development—is undoubtedly a major factor in the loss of some species. Fire provides routine opening of habitat by controlling woody plant species, a necessary requirement for many plant communities. Some species require fire to stimulate reproduction. An example is the American chaffseed (*Schwalbea americana*). This species was once found with frequency from Massachusetts southward throughout the eastern United States west to Texas. Now this species is so rare it is federally listed as endangered. In Maryland, this plant was historically found only in Worcester County. Without fire this species is quickly lost. The only location this species is still found in the mid-Atlantic is the relatively frequently burned pine barrens of New Jersey.

Effects of fragmentation

The highly fragmented nature of the Maryland landscape presents a major challenge to maintaining native plant communities and species. Ideally, where connections do exist they need to be maintained and where none exist they need to be created. However, there are severe limits as to what may be "protected" in the long-term. Isolated fragments of rare natural communities containing populations of rare plants, as a practical matter, cannot all be managed with equal effort and there is no one strategy to protect them all.

Fragmentation of habitats is a frequent, but not necessarily inevitable, result of development. Ecologists have been studying the effects of fragmentation at various scales for decades, arriving at a general consensus on the overall effects of fragmentation (Fahrig 2003).

Figure 17. National, State and county parks are shown in green borders. It is evident from this photo that even preserved public land areas are highly fragmented.

Most important of these effects are alterations in patterns of important life-history components of organisms (dispersal, reproduction, gene flow and mortality), which result from increasing isolation of habitat fragments. At some threshold the probability of an organism or of seed/pollen moving between patches becomes so unlikely that it is essentially zero. Unless connections are re-established between these habitat patches, each population then becomes a "remnant" or residual population with an increased extinction risk owing to the vagaries of small population size: genetic drift, inbreeding and unpredictable events (Lande 1987, 1988; Frankham 1996). Thus, the plants or animals that evolved and adapted to a historical landscape in a functioning ecosystem find themselves in an entirely different environment. (Tilman et al. 1994; Fahrig 2002; Hanski and Ovaskainen 2002).

Visible impacts of fragmentation and altered ecosystems

A large number of species considered rare, threatened or endangered require frequent disturbances (i.e., early successional habitats). Many of these species are best described as pyrophytic (fire-loving). Given the loss of a natural fire regime across our landscape, these disturbance-dependent species are now located only in manmade or maintained habitats, the most significant of which are powerlines and roadsides. We will never know the historic frequency with which fire impacted habitats and much debate surrounds the topic. Yet, even without this knowledge, clues to pre-settlement habitat conditions are found where the species are still present. Numerous rare species are known only from roadsides and powerlines because these habitats mimic a natural habitat type no longer provided in our landscape.

One area that illustrates this well is the Brookview area of Dorchester County. The Brookview area supports over a dozen species considered rare by the State. Most of the populations in this area are located along powerlines and roadsides. Most notable of these are the cream-flowered tick-treefoil (*Desmodium ochroleucum*), Skinners agalinis (*Agalinis skinneriana*), long-bristled Indian-grass (*Sorghastrum elliottii*) and the showy aster (*Eurybia spectabilis*). These species are all known from very few sites in Maryland and are located within 2.2 miles from one another. Habitats where these species are found in other states are described as "dry open woodlands," "grasslands" or "pine barrens," all of which are open lands with fewer trees than the dense forests currently found in the Brookview area. To support these species, this area must clearly have been a more open and frequently burned habitat in earlier times. The roadsides and powerlines here today are simply acting as refugia for these species. The example at Brookview is only one of numerous examples across the State. Many species that are listed as rare in Maryland have no known "natural" occurrence in present-day Maryland, with all populations known only from roadsides or powerlines.

In all likelihood, the paucity of native plant species existing in many of the small undeveloped plots in Maryland is due in part to the effects of fragmentation, although it would be impossible in most cases to separate this effect from that of invasive non-native species and white-tailed deer browsing.

Existing initiatives to address development and fragmentation

Growth Policy

The Maryland General Assembly enacted a series of major laws in the 1990s: the 1992 Economic Growth, Resource Protection and Planning Act and the four 1997 Smart Growth Initiatives.

The 1992 Economic Growth, Resource Protection and Planning Act articulates the State's growth policy through seven visions (the General Assembly added an eighth vision in 2000 and updated the visions in 2009) centered on concentrating development in suitable areas, protecting sensitive areas and establishing funding mechanisms to achieve the visions. The Act also requires local jurisdictions to address these same visions in their comprehensive plans. The Smart Growth Initiatives provide incentives to better locate new growth, protect rural land resources, and encourage stewardship of the Bay. By concentrating development in suitable areas, environmentally sensitive areas are preserved and infrastructure impacts, such as construction of new roads, are reduced. It has been estimated that by implementing some basic smart growth principles, developed land could be reduced from a projected 400,000 acres to about 110,000 acres while accommodating the 1 million people and 600,000 new jobs expected by 2035. In addition, State resources have been made available to preserve land outside of designated development areas. Similarly, the Sustainable Growth and Agricultural Preservation Act of 2012 encourages planning for development in some areas and prohibiting major residential subdivisions in other areas planned for preservation and conservation.

Building on these legislative initiatives, PlanMaryland (Maryland Department of Planning 2011) is a State-wide policy that directs State agencies to target their resources to help achieve smart growth at the local level and counties and municipalities to identify their growth and preservation areas to meet land use, planning, and development goals. Of the 12 Planning Visions proposed in PlanMaryland, two outline the conservation of resources and protection of the environment, including identifying and protecting lands and waters integral to the preservation and protection of environmentally sensitive and ecologically significant resources from the impacts of development. These two Visions are to be achieved through local comprehensive plans that are designed to preserve and protect the integrity of the State's important natural and ecological resources from encroachment and the impacts of incompatible land uses. Local jurisdictions are required to include the 12 Visions in their comprehensive plans and implement them through zoning ordinances and regulations, as well as address conservation of sensitive areas in plan updates.

Priority areas for conservation and identification of sensitive areas have been identified through GreenPrint, a web-enabled map showing the relative ecological importance of every parcel of land in the State. This map includes "Targeted Ecological Areas," lands and watersheds of high ecological value that have been identified as conservation priorities by DNR, including as targets for Program Open Space. These areas represent the most ecologically valuable areas in the State and include large blocks of forests and wetlands, rare species habitats, aquatic biodiversity hotspots and areas important for protecting water quality. One of the contributing features to GreenPrint is the GreenInfrastructure, a network of large undisturbed land areas (hubs) connected by designated pathways for the movement of wildlife (green corridors). Hubs include large blocks of contiguous interior forest (containing at least 250 acres, plus a transition zone of 300 feet); large wetland complexes, with at least 250 acres of unmodified wetlands; important

animal and plant habitats of at least 100 acres, including rare, threatened and endangered species locations; unique ecological communities; migratory bird habitats; and relatively pristine stream and river segments (which, when considered with adjacent forests and wetlands, are at least 100 acres) that support sensitive aquatic organisms. GreenInfrastructure maps have allowed local governments to enhance their efforts to provide open space, recreation lands, and natural areas, and provided a focus for local land trusts and citizen groups.

Critical Area Program

The Critical Area Act, passed in 1984, created a program to oversee the development and implementation of local land use programs relative to the "Critical Area"—all land within 1,000 feet of the Mean High Water Line of tidal waters or the landward edge of tidal wetlands, and all waters of and lands under the Chesapeake Bay and its tributaries. The goals of this program include conserving fish, wildlife, and plant habitat in the Critical Area through the preservation and maintenance of a 100-foot, naturally vegetated, forested buffer (recently proposed as a 200-foot buffer under some circumstances); protection of nontidal wetlands; and protection of plant and wildlife habitats that are significant from a State-wide or local perspective because of their rarity (including for State listed species). Significant habitats that receive protection include riparian forests (forested areas of 300 feet in width along streams and the Bay's shoreline), relatively undisturbed tracts of forest over 100 acres in size, certain plant and animal communities that are the best examples of their kind in Maryland, and other areas determined to be of local significance. Two approaches to habitat protection in the Critical Area have been adopted by local jurisdictions: (1) designation of areas around significant habitats in which disturbances are prohibited; and (2) protection programs which employ the acquisition of the habitat, conservation easements, cooperative agreements with landowners or other similar measures. In addition, disturbance in the 100-foot buffer area may require planting of native species or allowing natural regeneration for revegetation.

Program Open Space: Conservation through Acquisition of Property and Property Rights

Maryland’s Program Open Space was a landmark conservation initiative when it was conceived in 1968. Funded by a dedicated tax of ½ of 1% on most real estate transfers, the program directly linked the rate of State land conservation to the rate of land development. The program currently generates between 100 and 200 million dollars per year. Much of this funding has gone to conserve natural habitats that provide significant plant community protection. A significant portion of the Program Open Space funds are transferred as block grants to county governments to acquire and develop recreational facilities such as playgrounds and ball fields. Over the past 15 years, an increasing amount of Program Open Space funding has also gone to easement programs to protect farmland, scenic vistas and rural landscapes.

The transfer tax-based link between property development and conservation was designed to pay generously during good fiscal times and to constrict during economic recession. During times of fiscal constriction, however, Maryland government has regularly used Program Open Space monies to shore up deficits in State accounts unrelated to conservation.

Maryland has protected more than 400,000 acres of land through Program Open Space. Approximately one fourth of this number is comprised of conservation easements of various sorts. The trend toward easement acquisition over fee simple acquisition has been driven by numerous factors including:

- The relative attractiveness of private landowners being able to monetize their land holdings without altering their property
- The highly effective mechanism of using third party land trusts as real estate service providers
- The assumption that land protection measured in acres is homogeneous, and that easement ownership is as effective or more effective than State ownership
- Reluctance on the part of DNR land management units to accept ownership of new lands in a climate of declining personnel and fiscal resources

Maryland DNR uses a computer model that assigns a numerical score to all lands being considered for protection with Program Open Space Funds. The model is used consistently and provides the basic function of preventing the acquisition of ecologically insignificant lands with conservation dollars. However, land acquisition is still mostly conducted in an ad hoc manner as property is offered to the State or comes on the market in areas contiguous with existing managed areas.

A long-range strategy for land acquisition is a laudable goal, but the reality is that only a small percentage of the lands that might be identified as ecologically significant will come onto the market in a given year. Program Open Space monies are regularly transferred into the general fund during times of shortfall, so it would be impractical to hold back funds waiting for the most significant properties to become available. On the other hand, to designate tens of thousands of acres as acquisition 'targets' would have broad implications. The de facto expression of interest by the State to purchase land could raise unreasonable landowner perceptions of value and even distort land valuations in heavily targeted areas. In addition, the public targeting of huge land areas in what would be mostly the relatively undeveloped rural counties would almost certainly raise concerns about the effects of a large-scale conversion of private property to public ownership on the local tax base and economy.

Role of education and outreach in public support for conservation

Summary: Public support is essential if Maryland's native plants and their habitats are to be preserved. In addition to direct public outreach, increasing public appreciation for Maryland's botanical heritage can be accomplished through volunteer programs that engage citizens in conservation activities.

Public support for conservation of Maryland's botanical heritage is crucial. Public understanding of the importance of native plants, as well as the harmful impact of invasive plants, both in the wild and in the trade, will be key to preserving our native biodiversity. Existing education and volunteer-based programs can make significant contributions, and these could be enhanced.

For example, the Maryland Master Naturalist program, coordinated through University of Maryland Extension, engages citizens as stewards of Maryland's natural ecosystems and resources through science-based education and volunteer service in their communities. For a fee, the program provides 60 hours of classroom and field experience for volunteers, who then go on to provide 40 hours of service each year. A wide variety of volunteer opportunities are possible, including environmental restoration projects, education, public awareness campaigns, and field research. The Master Naturalist program began in Colorado in the 1970 and exists today in 34

states. Maryland's program was created between 2008 and 2011, and currently is active in the Coastal Plain and Piedmont Regions with extension to the Mountains planned for 2014.

Further opportunities could be provided for volunteers to assist with plant conservation tasks. Conserving our native heritage takes time and effort. Staff reductions have led to fewer eyes in the field surveying for the presence or absence of listed native species and for invasive plants. An enhanced coordinated volunteer program within DNR, could help while, at the same time, educating citizens about the value of Maryland's natural heritage. Possible volunteer opportunities might include: site monitoring; locating, verifying and scanning older paper records of native plants; and assisting with surveys. Of course, to be successful, any volunteer program requires staff planning and supervision.

Recommendations for improved conservation of natural habitats and listed (rare, threatened and endangered) species

To address the need for enhanced conservation of natural habitats, including those supporting rare, threatened and endangered plant species, we recommend reinforcing the foundations of the Natural Heritage Network. This is an international network that tracks and monitors species using consistent methodologies, and whose Maryland component is the Wildlife and Heritage Service within the Department of Natural Resources (DNR).

These recommendations posit that static or declining budgets, at least in the Wildlife and Heritage Service, are likely to continue for the long term, given the manner in which the Service is funded. They also recognize that the Service has limited capacity for on-the-ground conservation management. Nevertheless, with modest additional resources it would be possible to accomplish significant conservation tasks:

(a) Produce and maintain high-quality and current data on rare plants housed in our conservation database (Biotics) and the Norton-Brown Herbarium.

(b) Vigorously curate the basics (rank and status) with up to date, defensible and scientifically sound documents.

(c) Produce the highest quality science in whatever projects can be funded and publish those results so that what we learn may be transferred to the conservation community at large.

(d) Produce clear, obtainable conservation goals for priority plant species including management and recovery plans.

Thus the Work Group makes the following specific recommendations:

1. **We recommend expanding the active stewardship component within the Wildlife and Heritage Service to include four regional stewards**. Many of our rare, threatened and endangered plant and animal species require habitat management to maintain and protect viable populations. Currently, the Wildlife and Heritage Service can only undertake a few high priority projects per year. Regional stewards would be chiefly responsible for on the ground monitoring and management activities in each region (Eastern, Southern, Central, Western).

2. **We recommend a short-term assistant to the State Botanist would be responsible for assisting with updating and reviewing rank and status, annotating database records and processing herbarium data**. The Wildlife and Heritage Service employs a single full-

time botanist (the State Botanist) who is responsible for setting plant conservation priorities and whose chief responsibility is maintaining the list of rare, threatened and endangered plant species. The State Botanist is continuously revising this list but progress is limited owing to additional administrative duties.

3. **We recommend assistance by a professional database management contractor (in the short term) to overhaul and eliminate the data entry backlog in Biotics that is overwhelmingly botanical in nature**. The conservation database administered by the Wildlife and Heritage Service (called "Biotics") has a critical backlog of data for entry. This database is essential to the conservation of Maryland's biodiversity.
4. **We recommend establishing a special projects fund, administered by the Wildlife and Heritage Service's Director, with allocation based upon critical inventory and monitoring gaps**. Inventory and monitoring of rare and vulnerable plant species and communities are poorly funded at present.
5. **We recommend establishing a research fund, administered by the State Botanist to address critical knowledge gaps for priority species**. At present there are no specific funds available for research specifically directed at Maryland plants.
6. **We recommend encouraging State conservation programs, including easement-based programs funded through Program Open Space, to target and design for the long-term conservation of significant botanical communities.**
7. **We recommend that DNR engage and perhaps formalize relationships with volunteer-based programs like the Maryland Master Naturalists to reduce the number of administrative hours shouldered by DNR biologists and ecologists**. Administrative and database tasks usurp the time of specially trained professional DNR staff. We caution, however, that volunteers cannot perform every task and that there will be tradeoffs between work accomplished and an increase in the workload to manage and coordinate those volunteers.
8. **We recommend that dedicated funding be allocated to the Norton Brown Herbarium at the University of Maryland, College Park in order to maintain its critical functions.** Recognizing the irreplaceable nature of the biodiversity collection and the uncertainty regarding its future, we strongly recommend that the State sustain essential funding for core staff comprising the director of the herbarium, a curator and collections manager.
9. **We recommend considering an update to the list of Nontidal Wetlands of Special State Concern**. This list, maintained by Maryland Department of the Environment, identifies nontidal wetlands that are subject to more stringent review requirements than other nontidal wetlands, often resulting in protection for rare plant species and/or high quality natural communities.

Challenge: Devastation from the over-abundance of white-tailed deer

SUMMARY: Mile after mile of Maryland forests have a park-like appearance: many tall trees, but almost nothing growing on the ground. The ground cover, when present, often turns out to be non-native and invasive. The native wildflowers are absent, as are the native shrubs and saplings, along with the benefits they provide. These changes are occurring rapidly, in some cases within the last 10 years.

The population of white-tailed deer (*Odocoileus virginianus*) in the mid-Atlantic region has rebounded from low levels at the turn of the 20th century to levels today that are generally agreed to be higher than at any time in history. Landscape fragmentation and the rise of suburbs have created excellent conditions for this denizen of successional and edge habitat. Deer are highly adapted to habitat disturbance and quick to become accustomed to close proximity to humans. The same suburban habitats to which deer so easily acclimatize are generally impractical or unattractive to human hunters, their last remaining predator except for the automobile. Even in the most rural parts of Maryland, the number of deer hunters has been in decline for decades, even as opportunity and hunter success are at all-time highs. It has become evident that hunting as it exists today cannot be relied upon as the primary population management tool for our deer herd.

The effect of this super-abundance of herbivores on plant populations has been well studied, particularly in regard to its effect on forest regeneration. In Maryland, there are also long-term data documenting the role of deer in the suppression of herbaceous plants that are preferred browse plants. Some native plants (such as Canada yew and tall larkspur) remain in Maryland only in those few areas inaccessible to deer. Effective control of deer abundance is a necessity if we are to preserve Maryland's botanical heritage.

The deleterious impact of the over-abundance of white-tailed deer

Simply stated, we have more white-tailed deer in Maryland than our ecosystems can handle, especially in our suburban areas. They have become change agents to our environment, habitats, human lifestyles, and to other wildlife and plant communities. The white-tailed deer can be characterized as a "keystone herbivore" in the eastern deciduous forest (Waller and Alverson 1997). A keystone herbivore is a species that affects the distribution and abundance of many other species, that can affect plant and animal community structure at multiple levels, and whose abundance has a correspondingly heavy impact on the entire plant and animal community in which it lives.

The feeding and browsing of white-tailed deer has profound effects on Maryland's plant and animal communities. Twenty years ago researchers in Maryland found that as deer densities became higher and their browsing increased, there was a marked decline in the number of wildflowers, songbirds, and tree seedlings in the forest habitat (deCalestra and Stout 1997). By

Figure 18. This photo shows the contrast between the understory inside and outside an 8-10 year old deer exclosure fence at Middle Patuxent Environmental Area in Howard County. Photo by Cheryl Farfaras, Howard County Recreation and Parks Department

2004, the University of Maryland Extension was informing the forest landowners in Maryland of the threats the growing deer population posed to the natural regeneration of the forest resource.

While deer consume many non-native plants, deer prefer native plants in the forest and edge habitats, as these plants are the food sources with which deer coevolved. When deer populations are greater than their habitat can sustainably support, over-browsing occurs, removing these native plants from the understory and shrub levels of the forest. This situation has a two-fold deleterious effect: (1) native plants are removed at a rate that does not allow for regeneration; and (2) once freed from competition by native plants, invasive non-native plants become established.

Deer contribute to the spread of non-native invasive plants. They preferentially consuming native plants, reducing the ability of native plants to withstand competition from non-natives (Eschtruth and Battles 2008; Kalisz et al. 2003). They also spread the seeds of non-native plants (Myers et al. 2004).

Among the plants over-browsed by the deer are the tree saplings, which would under normal conditions form the basis for natural succession and regeneration of the native forest. Many Maryland forests contain few or no tree saplings. As the existing mature trees die or are removed, they are not replaced and thus the forests themselves are gradually dying.

Removal of the forest understory diminishes food sources and nesting sites of other forest-dwelling small mammals and birds, as well as the deer themselves. The effects to our forests and native plants are obvious to the trained observer—and in many cases to the untrained observer. Published and unpublished data point to the severity of the problem, several of them specific to Maryland. Particularly telling is documentation of the interactions and damage caused by deer to rare plant and animal species. Deer herbivory is so great at a site in Worcester County that flowering stalks of wild lupine (*Lupinus perennis*), a threatened species, are scarce. These flowering stalks are essential to the life of a globally uncommon and endangered frosted elfin butterfly (*Callophrys irus*) found at the site (Frye 2012).

In another example, 19 of the 21 orchid species of the Catoctin Mountains of Frederick County have seen a significant decline. This decline is almost perfectly correlated to the deer harvest data for the county, a surrogate for deer population data (Knapp and Wiegand, unpublished data). Additionally, a rare oak forest type was recently documented in Talbot County. This forest is a

very wet woods with a diversity of mature oak species. Unfortunately, the deer herd of the area is so large there is virtually no oak regeneration visible in the understory. If deer are not checked, this rare forest will fundamentally change or be lost entirely.

Damage from deer over-abundance is not confined to the impact on plants and wildlife. Deer inflict significant damage on Maryland's agricultural crops. Deer also have a detrimental effect on human health. On a typical day in Montgomery County, five motorists strike deer (Morse et al., 2013). One in every 141 Maryland motorists will have a deer collision in the next 12 months, while the national chance of striking a deer are 1 in 171 and in neighboring West Virginia it is 1 in 40 (Purcell et al. 2013). The average deer-vehicle collision in Maryland results in an insurance claim of about $3,000 (Kays and Timko 2011, Eyler 2013). However, a very real and serious result of these incidents is bodily injury and the sometimes fatal outcome for the occupants of the vehicle. And it almost certainly means the demise of the deer involved. The proximity of deer to human habitation has also resulted in an increase in the transmission to humans of tick-borne diseases such as Lyme disease.

Figure 19. Ten Mile Creek in Montgomery County, which feeds the Little Seneca Reservoir. The health of the forest surrounding the reservoir is critical to the water supply of thousands of people. Photo by Janice Browne, janicebrowne.com.

How the white-tailed deer herd in Maryland came to be so large

As early as the mid-1600's Maryland was enacting laws and regulations related to game species. The first legislation on white-tailed deer in Maryland was in enacted in 1729. In 1773, due to declining numbers, it became necessary to restrict killing deer for a three-year period, with a season established for September and October. Despite these early efforts, by the 1800's deer were mostly relegated to the western portions of the State. The combination of timber harvesting, clearing land for agriculture, hunting, and the industrial revolution were major factors in the near extirpation of Maryland's white-tailed deer. Moreover, the natural predators of the white-tailed deer, namely the mountain lion (*Puma concolor*) and the timber wolf (*Canis lupis*), had been effectively extirpated from the State by the early years of the last century, leaving humans as the only significant predators of deer.

State management to increase the white-tailed deer population began in earnest in 1937 with passage of the Federal Aid in Wildlife Restoration Act (commonly known as the Pittman-

Robertson Act). Some early management techniques included: no hunting in some years, antlered-deer-only hunting, requiring hunting licenses, establishing seasons and bag limits, and restocking by importing deer from the northern Midwest. In addition, from the 1920's into the 1970's, state refuge areas (Wildlife Management Areas) were established for deer and other wildlife and game species. During this same period, and especially after World War II, Maryland's human population grew rapidly, and suburban development expanded into formerly forested tracts and agricultural lands. These factors—available food from farms and rich suburban landscapes, coupled with management practices aimed at protecting the deer harvest—created an ideal environment for deer to thrive and multiply, and thus the deer herd increased to an extent never anticipated.

A thumbnail look at the harvest of deer through hunting efforts during this period of human societal changes in Maryland from the mid-twentieth century until today, reveals the story of the deer herd's growth. It also reveals the decline in the number of hunters after a peak in 1968.

Year	Hunter Harvest	Farmer Harvest	Est. Deer Population	Resident Hunting Licenses
1940	375			75,925
1950	890			114,207
1960	4892			150,482
1968	5967			182,990
1990	44,279	2,910	134,942	116,713
2000	82,426	11,473	286,378	97,216
2010	95,833	8,245	234,718	79,697
2012	85,129		222,802	77,488

Table 3. Historical trends in white-tailed deer harvest, 1940-2012. Based on data supplied by B. Eyler.

Private hunters are responsible for most of the deer harvest in Maryland, taking approximately one third of the population annually. White-tailed deer are also harvested by farmers, who can receive permits after demonstrating damage to their field crops (and their livelihood) caused by deer. For many years, since the extermination of wolves and mountain lions and the reduction of black bears (the natural predators of deer), hunters have been the primary control on the deer population. But the number of licensed hunters is declining. Doubtless the continued apparent success of hunting efforts is a function of the large and ubiquitous deer herd. However, hunters do not have access or choose not to pursue deer in all of the habitats that support the herd (e.g., suburban communities, nature preserves, large private land holdings denied to the hunting public). Many landowners are unaware of the significant protection from liability conferred by the Landowner Liability and Recreational Access Law (Annotated Code of Maryland, Natural Resources Article, Title 5-1101 et seq; see Kays 2008).

Bag limits for Maryland hunters could be said to be "oversaturated," meaning that the majority of hunters do not take as many deer as they are legally entitled to do. The current annual bag limit in much of the State allows for as many as a total of 36 deer to be harvested per hunter throughout the various deer seasons. While this generous bag limit no doubt reflects the relationship of the deer herd population and estimated license sales, it is not realistic to expect the average hunter to have the necessary access, available time or resources, or the need to harvest more than several deer annually.

White-tailed deer greatly benefit from Maryland's lush and diverse landscape plantings as well as from the protected green spaces, stream corridors, floodplains, forests and wetlands resulting as the Maryland landscape has changed to accommodate suburban development. Deer browse to these man-made suburban habitats as well as to the portions of the land (forest remnants and stream corridors) preserved to balance the effects of development is both costly (loss of nursery stock) and damaging to the remaining natural habitat.

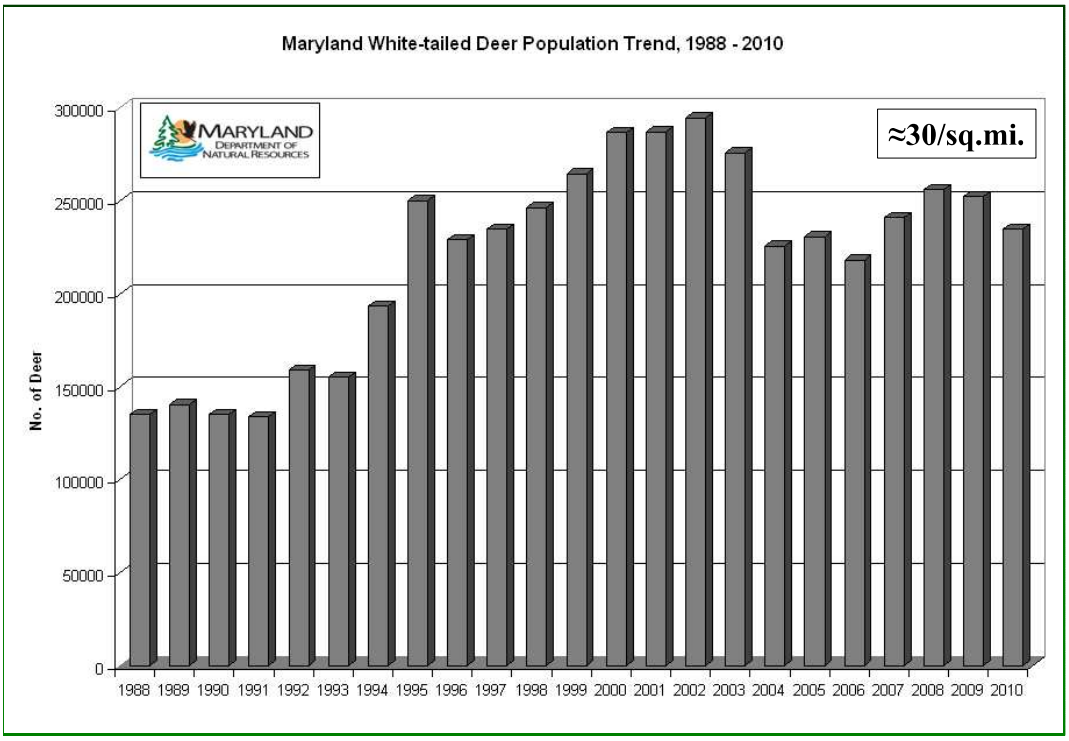

Figure 20. Maryland White-tailed Deer Population 1988-2010. Source: Maryland Department of Natural Resources.

Currently the average deer density in Maryland is estimated at about 30 per square mile (Eyler 2013), with estimates as high as 95 per square mile in some suburban areas (Gilgenast et al. 2009). Aerial surveys by helicopters equipped with forward looking infrared radar (FLIR) conducted in Howard County found that deer densities in some very localized areas may be as high as "hundreds" of deer per square mile (personal communication P. Norman, Howard County Recreation and Parks). By contrast, estimates of the maximum deer density that allows healthy forest regeneration might vary from 8 to 20 per square mile. In what is considered by many professionals as a landmark deer density study, deCalestra and Stout (1997) reviewed and studied a number of eastern forest sites in Pennsylvania with different deer densities, and observed that deer densities higher than about 15 per square mile had deleterious effects on the forest ecosystem.

Alternative methods of deer management

"The lethal control of deer via regulated hunting remains the most effective way to balance the deer population with environmental and cultural concerns on a landscape scale." (Maryland White-tailed Deer Plan 2009-2018)

Unfortunately, attempts to decease deer abundance using currently available methods to reduce doe fertility have shown this technique to be expensive and of limited utility, especially for large areas. The doe must be captured, anesthetized, treated, revived and released, all at significant cost ($700-$1000 per doe per treatment). In a study performed in Maryland, only 47% of the treated does were sterile in the second year after treatment (APHIS 2011). In addition, this method is not practical for unfenced tracts accessible to untreated deer, let alone for treating the large, widespread, free-ranging deer population that exists in Maryland (Eyler and Timko 2013). Nevertheless, fertility reduction could have a role, albeit a limited one, among various deer management techniques.

Techniques to exclude or repel deer vary greatly in cost, efficacy, and duration of effectiveness. None of these exclusion techniques addresses the fundamental issue of deer over-abundance and its effects on natural habitats.

- Fencing of various types can be effective but is not always a practical solution to damage or loss from deer feeding activities. It is most effective on individual plants or small areas such as in residential landscapes. Cost and aesthetic considerations as well as the necessity for diligent maintenance tend to discourage its use. Electric fencing can be effective for large home gardens, small orchards, and crop fields, although deer may endure the shock if hunger drives them to seek forage on the other side of the fence. Fencing of large natural areas is plainly impractical.
- Repellants have variable efficacy and they require frequent application due to rapidly growing shoots and weather effects on the repellents (e.g., rain or heavy dew). Repellants must be applied during mild weather and therefore can offer little if any protection to the plants during the winter months. Repellants are rather costly, may damage some plants, and can exhibit noxious and/or unaesthetic product residues on plant parts. Repellents, as with fencing, offer no solution to deer over-abundance nor are they practical for large areas.

*Figure 21. Pinxterflower (*Rhododendron periclymenoides) *is a Maryland native shrub that often shows evidence of deer browse. Photo by Janice Browne, janicebrowne.com*

Recommendations to address the over-abundance of white-tailed deer

Effective control of white-tailed deer abundance is a necessity if we are to preserve Maryland's botanical and wildlife heritage. This challenging and complicated issue will require the cooperation of a broad range of partners including government agencies, sportsmen, farmers, and citizens seeking innovative ways to reduce deer numbers for the benefit of native habitats, suburban landscapes, the economy, public safety, and the well-being of Maryland's deer herd.

The Maryland White-tailed Deer Plan 2009-2018 presents a thorough and comprehensive approach to a variety of management opportunities and techniques. The Work Group encourages DNR and other land managers (as applicable) to actively pursue these opportunities with emphasis on the following.

1. **We recommend modifications in hunting laws/regulations/practices.** This would include: season/bag limits adjustments to very localized flexibility (Community Based Deer Management), and adjusting safety zones for archery pursuits.
2. **We recommend increased outreach and education on Maryland's Landowner Liability and Recreational Access Law.** Private landowners are more likely to invite hunters onto their lands if they are aware of the protection from liability that this law affords.
3. **We recommend encouraging efforts by State lands managers to reduce white-tailed deer damage on public lands.** This may be done, for example, by increasing hunter access, giving more hunters more time afield, and by developing management plans directed at restoring regeneration of forest trees and other native plants**.**
4. **We recommend encouraging and facilitating more managed deer hunt programs with volunteer hunters and more programs with certified sharp shooters after regular seasons**.
5. **We recommend investigating and as appropriate implementing methods to increase donation of harvested deer for community food banks and homeless shelters.**
6. **We recommend fostering education, public awareness, and endorsement of hunting as a management tool necessary for habitat conservation, protection and control of the deer herd, and for the positive impact of hunting on State and local economies**.
7. **We recommend continuing to monitor research and development in deer biological fertility controls**. While unlikely to be effective to treat Maryland's large, free-ranging white-tailed deer population, fertility management could have a role, albeit a limited one, among various management techniques.

The Work Group also makes the following recommendation.

8. **We recommend an investigation under DNR's leadership of permitting a regulated commercial market in Maryland for wild-harvested venison, with input and open discussion from all interested stakeholders**. Input from DNR advisory committees, other stakeholders within State government, sportsmen and conservation groups, as well as non-traditional partners, may provide the way in which over-saturated bag limits per hunter (as viewed by some) can benefit the State, native habitats, and the local economy.

Challenge: Insufficient prevention and control of biological invasions

SUMMARY. The continuing introduction, establishment and spread of invasive species is devastating Maryland's native plants and ecosystems, and is inflicting major and long-lasting harm to the State's agriculture, to its economy and to human health. In Maryland, there are over 400 species of invasive plants, invasive insects, and plant pathogens that threaten the health and survival of the State's biological diversity and its botanical heritage (EDDMapS 2013). Primarily through Maryland Department of Agriculture (MDA) and Department of Natural Resources (DNR), Maryland has had some success in preventing or slowing the establishment of some potentially very harmful species. In some cases, finding a suitable biological control (an insect or disease) may be the only hope. Currently, the State's agencies do not have the resources they need to take the actions necessary to protect and conserve Maryland's botanical heritage and its biological diversity from the threat of invasive species. Increased education and involvement of Maryland citizens in invasive species issues is crucial.

What is an invasive species?

As nationally defined, an invasive species is an "alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." An alien species is "any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to a particular ecosystem." By contrast, a native species is one that "other than as a result of an introduction, historically occurred or currently occurs in [a particular] ecosystem." (Exec. Order 1999)

Alien species, also called exotic, non-native, and non-indigenous, include all types of organisms (plants, insects, mollusks, fish, reptiles, birds, mammals, fungi, bacteria and viruses) that have been introduced to places where they did not historically occur. Alien species are transported, accidentally or intentionally, by humans; they occur in locations to which dispersal by natural means—air, water or animals—is highly unlikely. These newcomers are from other continents, other countries and even from other ecosystems within the United States.

Most non-native species are not harmful or invasive. Most of our food crops and domesticated animals are not native and they pose little or no problem. An organism is considered invasive when it becomes established and self-sustaining in its new habitat, and begins to reproduce and spread aggressively at the expense of native species and habitats. An invasive species typically arrives without the naturally occurring complement of parasites, pathogens, herbivores and competing organisms with which it has coevolved over millennia and which regulate its growth and survival in its native habitat. Free from these natural checks, introduced species adapt and thrive in their new environments. Two examples of major invasive species in the United States are chestnut blight (*Cryphonectria parasitica*), a fungal disease, and the European gypsy moth (*Lymantria dispar*), an insect. Both species were brought in from elsewhere, became established

and quickly spread beyond managed systems to significantly and forever affect eastern hardwood forests.

Invasive species generally have characteristics that help them succeed in their new environment. They can reach reproductive maturity early; produce abundant seed or eggs; reproduce asexually; adapt to a wide range of temperature, moisture or soil conditions; or undergo changes that make them more competitive in their new habitats. While not all non-native invasive species display all of these characteristics, any of these traits can convey an advantage over a native. Also, invasion often involves a lag time of many years; populations of a non-native species increase unheeded until a tipping point is reached after which eradication is impossible and even control is prohibitively expensive (see Figure 22). We must then settle for minimizing the invader's impacts by reducing its numbers, containing it geographically, removing satellite populations and hoping for the development of an effective biological control agent.

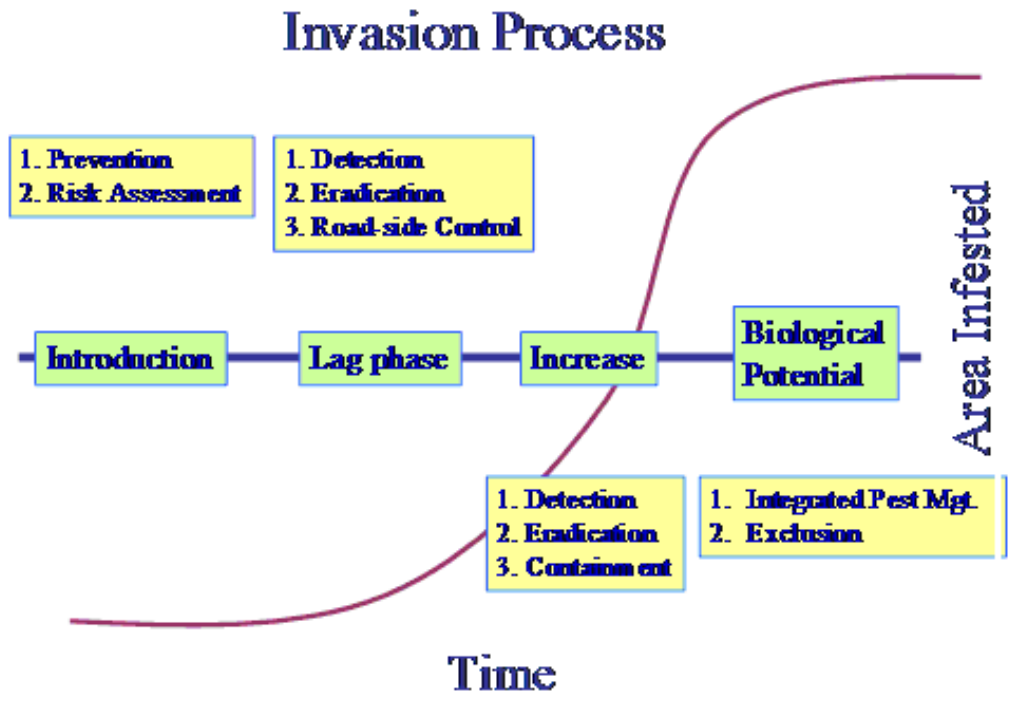

Figure 22. Time course of an invasion framework to use during management planning. Source: Invasive Plant Management, CIPM Online Textbook, Dr. Tim Prather, University of Idaho

What harm do invasive species cause?

Economic consequences

Invasive species cause disruption to agriculture, forestry and fishery operations, with major economic consequences. Impacts range from reduced yields of food and forage crops and timber, all economically valuable, to reductions and loss of fish and shellfish. A clear example is the invasive oyster parasite *Haplosporidium nelsonii*, or MSX, which decimated Chesapeake Bay oyster populations in the 1960s and 70s. It was introduced when the natural host, the Japanese oyster, was brought to the East Coast of the United States for aquaculture testing. In 2011, DNR promulgated a regulation prohibiting felt-soled waders, due to their superior capacity to spread the invasive alga *Didymosphenia germinata*, or rock snot, from trout stream to trout stream. In this case, both the invader and the regulatory response it precipitated had economic consequences.

The cost of invasive species nationally has been estimated at $120 million per year in environmental damage and losses (Pimentel et al. 2005).

Human health impacts

Invasive insects and pathogens like the Asian tiger mosquito and West Nile virus, both introduced to the United States in the last 25 years, are now well established and have cost millions of public and private dollars to monitor and manage. Center for Disease Control researchers estimated the average cost per case of West Nile virus that would be saved by use of an effective vaccine to be $34,200, and the cost of vaccinating 100 million people to be about $8.7 billion (Zohrabian et al. 2006). These two species alone have discouraged Marylanders from participating in outdoor recreation, and have caused illness and even fatalities in susceptible groups. The sap of giant hogweed (*Heracleum mantegazzianum)*, a federally listed Noxious Weed, causes such photosensitivity that it can cause second degree burns and, if in contact with the eyes, blindness. The ornamental shrub Japanese barberry (*Berberis thunbergii)*, which increasingly infests Maryland forests, is linked to higher incidence of Lyme disease-bearing ticks (Williams et al. 2009).

Ecological impacts and harm to Maryland's botanical heritage

Invasive species can reduce numbers and diversity of native plants and animals and their ecological communities. Impacts include suppression of rare, threatened and endangered species, and increased expenses for management activities and restoration of damaged landscapes. The Mid-Atlantic Invasive Plant Council reports that approximately 300 species of non-native plants are invasive in natural areas in the mid-Atlantic region. The Maryland State Botanist estimates that 40% of Maryland listed rare plant species are threatened by one or more non-native invasive plants.

*Figure 23. (Left) Mile-a-minute vine (*Persicaria perfoliata*) easily climbs and spreads into floodplain forest canopies, blocking light to the plants it overtops. (Right) Chinese wisteria (*Wisteria sinensis*) strangles and kills mature trees. Photos by Kerrie Kyde.*

One plant presents an example of such impacts on several levels. The European plant garlic mustard (*Alliaria petiolata)* was introduced in New York in the mid-1800s as a pot and medicinal herb. It has spread and is now widely distributed in moist woodlands in all but 12 states and three Canadian provinces. Garlic mustard produces the same chemical signal as other mustard family species, including its botanical cousins, toothworts (*Cardamine spp*), which are the host plants for the rare butterfly, West Virginia white (*Pieris virginiensis*). Maryland's populations of this butterfly occur primarily in Garrett County, where garlic mustard is spreading through the forest understory and toothwort numbers are declining. The butterfly is drawn to oviposit on garlic mustard, but its eggs do not hatch, or hatch poorly, and its larvae cannot survive on this plant. Also, garlic mustard produces a root exudate that has been shown to inhibit the naturally occurring association of certain soil fungi—mycorrhizae—and tree roots (Roberts and Anderson 2001). All Maryland's hardwood forest trees need mycorrhizal associations to thrive. This is especially true when plants are seedlings, before they have well-developed root systems. Extensive infestations of garlic mustard in a Maryland forest can thus interfere with tree regeneration. Recent research indicates that the chemicals garlic mustard produces may directly affect germination of native wildflower seeds (Roberts and Anderson 2001).

Other examples of non-native invasive plants include:

- English ivy (*Hedera helix, H. hibernica*), Oriental bittersweet (*Celastrus orbiculatus*), Asian wisteria (*Wisteria sinenis, W. floribunda*) and other invasive vines overtop trees and shrubs, weigh them down, shade their foliage, girdle them and eventually kill them (See Figure 23).
- Lesser celandine (aka fig buttercup) (*Ficaria verna*), an herbaceous spring perennial, and Japanese knotweed (*Fallopia japonica*), a large shrub-like plant, thrive in floodplains where they suppress dozens of native spring wildflowers.

The spread of invasive plants also affects animals that depend on native plants for survival. Native plants support the growth and reproduction of native insects. Because native insects and plants coevolved over many thousands of years, most insects are adapted to the particular leaf chemistry and physical properties of specific plants. Although some native insects are able to consume invasive plants, especially those related to the native plants they are typically feed on, native plants produce much more insect biomass and many more insect species than non-native plants. Insects are the direct food source for other animals such as birds, reptiles and small mammals. They also provide valuable services to humans such as pollination, and aeration and nutrient cycling in soils (Tallamy 2009).

Non-native plants provide less beneficial food and habitat for animals than native plants. For example, oriental bittersweet (*Celastrus orbiculatus)*, heavily eaten by songbirds, does not supply the nutritive value they need to support the stresses of migration. Ornamental shrubs commonly planted at the suburban-forest interface can reduce nesting success of forest birds and may cause increased nest failure (Borgmann and Rodewald 2004, Johnston 2006).

Exotic insects and pathogens have recently been responsible for enormous losses of native plants, especially trees. Examples include:

- Hemlock woolly adelgid (*Adelges tsugae*), an insect native to East Asia, is currently causing widespread mortality of eastern hemlock (*Tsuga canadensis*) throughout much of its range including Maryland.
- Emerald ash borer (*Agrilus planipennis*), a beetle of Asian origin, is responsible for the death of millions of native ash trees (*Fraxinus spp*) in the United States. It is present in Maryland and it is not clear whether control and quarantine efforts will be adequate to prevent widespread mortality of ash trees.

Control of non-native invasive species in Maryland

Invasive species management consists of:

- Preventing their introduction and spread;
- Removing them by physical or chemical means;
- Introducing biological controls, that is, the microorganisms, predators and parasites that keep them in check in their native environments; and
- Reducing the over-abundance of white-tailed deer, which preferentially consume native plants.

Invasive species control in Maryland resides primarily with DNR and MDA. These agencies often act cooperatively with federal agencies and may receive funds from federal sources. [3]

[3] The **National Invasive Species Council (NISC)** provides high-level interdepartmental coordination of federal invasive species actions and works with other federal and non-federal groups to address invasive species issues at the national level. NISC's National Invasive Species Management Plan, most recently updated in 2008, serves as a comprehensive "blueprint" for federal action on invasive species, as well as NISC's primary coordination tool. For a list of Maryland and federal laws pertaining to invasive species, see dnr.maryland.gov/invasives/laws.asp.

MDA, primarily through its **Office of Plant Industries and Pest Management,** has significant responsibility for preventing the introduction and combatting the spread of invasive species. **DNR** does tracking and control work for invasive animals and plants on public land, working closely with MDA, especially on invasive species that affect State forests. Due to lack of funds in recent years, these capabilities have been substantially reduced. Outside funding including grants from federal agencies, supports some efforts, but these are typically short-term and project-based. When grant terms expire, the State agency often cannot continue work begun with outside funds.

The **Maryland Invasive Species Council** (MISC), established in 2000, is a voluntary non-incorporated "group of concerned scientists, land managers, business people and citizens acting to reduce the spread of invasive plants, animals and diseases." MISC members are drawn from State agencies, the federal government, academia and the private sector including for-profit and non-profit entities. In addition, MISC sometimes brings in relevant constituencies on an ad hoc basis. MISC's status as an informal organization means that it does not have paid staff and cannot receive or disburse funds. For projects that require funding, MISC has partnered with (among others): MDA, DNR, USDA, the University of Maryland, the Maryland Nursery and Landscape Association, and with other agencies and entities. Thus, despite its limitations, MISC is able to function as a coordinating body for emergency response to new invasive species, as a consensus-building organization, and as an information resource.

A number of states have legislatively created invasive species councils whose activities are funded by the state. These councils, which typically include representatives from state agencies, academia and the private sector, develop strategic management plans for early detection and rapid response, recommend and coordinate control measures, identify restoration and research needs, and coordinate among state agencies and adjacent states, among other activities. These councils may confer advantages, including the ability to hire staff if funds are available. Given the effectiveness of MISC, however, it was not apparent to the Work Group that a council of this type would be beneficial for Maryland.

The **Invasive Plant Advisory Committee** (IPAC), established by statute in 2011, was created to support the Maryland Secretary of Agriculture in developing approaches to invasive plants, in particular those introduced through horticultural channels. The IPAC was charged with adopting a risk assessment protocol, and using that protocol to rank plant species into two tiers. Tier 1 plants will ultimately be banned from production, sale or transport. Tier 2 plants may be sold and planted, but only with appropriate signage indicating their invasive nature. IPAC has adopted a weed risk assessment tool, but has not yet produced a tiered list of species, primarily due to the need for funds to pay a professional to complete assessments. Just this October, however, MDA has received federal funding that should allow assessments to be undertaken; IPAC anticipates the release of a two-tiered species list in 2014.

The **Mid-Atlantic Invasive Plant Council** (MAIPC), another voluntary organization, provides regional leadership to address the threat of invasive plants to the native species and natural habitats of the mid-Atlantic region. The council coordinates regional efforts to gather and share information on the identification, management and prevention of invasive plants, provide training and volunteer opportunities and to identify research needs. The Council is represented by members from Delaware, Maryland, New Jersey, Pennsylvania, Virginia, West Virginia, and the District of Columbia.

Early detection and eradication

The U.S. Department of Agriculture's **Animal and Plant Health Inspection Service (APHIS)**, along with the Department of Homeland Security, regulates the import into the United States of plants and animals (including insects) and conducts border inspections that prevent the import of a large number of invasive and potentially invasive species. Thus Maryland, along with the other states, depends on the efficacy of this federal inspection team to protect its borders from non-native species known to be invasive. Due to the volume and cryptic nature of many of these species, some escape detection and become established. In the last two years, APHIS has developed and begun using a weed risk assessment to predict the probability that an unknown exotic plant species will be invasive in the U.S. The agency is using this tool to support importation permit decisions for "plants for planting" that fall into the category of NAPPRA, Not Authorized Pending Plant Risk Analysis. IPAC has adopted the APHIS weed risk assessment model for its plant assessments.

MDA's **Nursery Inspection and Plant Certification** staff has responsibility to inspect all Maryland licensed nurseries for invasive plants and weeds, insect pests, and pathogens. In fact, it was during one of these routine inspections that emerald ash borer was first discovered in Maryland. In recent years, due to limitations in funding and staffing reductions, it has not been possible for existing staff to perform as many inspections as in the past.

In 2005 MDA and DNR developed the **Emergency Response Plan for Invasive Forest Pests**, to be activated when a new, invasive insect or disease species is detected and identified as a threat to Maryland's forests. Its purpose is to coordinate the response among state and federal agencies, academia, industry, and the public.

Four years ago, DNR formed an internal task force to advise the Secretary of Natural Resources on invasive species policy and regulation. Titled the **Invasive Species Matrix Team**, this group includes representatives from every DNR unit that deals with invasive species in some way. The group has conducted research, printed signs for aquatic invasive species identification and awareness, provided a point of contact for outside researchers and helped develop a K-12 invasive species curriculum for Maryland schools.

Illustrative Examples

Two recent examples illustrate the challenges inherent in combatting newly introduced invasive plant and animal species that pose a threat to Maryland's native plant populations.

Wavyleaf basket grass (*Oplismenus undulatifolius*) (WLBG) is a relatively newly discovered invasive species. WLBG was discovered in Patapsco State Park in 1996. It was at that time an unknown grass but it was identified and its presence published in 1999. It has continued to spread. Its seeds are extremely sticky and adhere in great numbers to clothes and to the coats of large mammals. By 2007, when DNR invasion ecologists first became aware of this grass, it was found to be spreading quickly, and exhibiting characteristics of a potentially threatening invasive species. In the following three years, DNR spent $115,000 to map and treat specific infestations, and attempted to raise additional funds to conduct basic life history research about the species and continue control work. During that period, WLBG was discovered to be widely distributed on thousands of acres of private land within Maryland; it was also discovered in Virginia, growing as far west as the Appalachian Mountains.

Dr. Vanessa Beauchamp of Towson University has conducted the first field studies of this species. Her recent research shows that WLBG exhibits the characteristics of a highly invasive species (Fulton 2013). In 2010 DNR abandoned efforts to eradicate it, believing it to be distributed well beyond public lands and lacking the funding or staffing to complete the work. DNR now attempts to minimize its spread by controlling newly discovered infestations. There is an active group of volunteers working under a DNR certified pesticide applicator to provide herbicide control in Patapsco State Park. Dr. Beauchamp's group has developed a smartphone application for volunteers to record sightings. See www.towson.edu/wavyleaf.

Lessons can be drawn from this example. Intensive inventory, mapping and research must be done quickly after a potentially invasive plant is discovered, or else eradication is impossible. However, funds for these essential functions were not available until it was too late, and the State had no mechanism for prioritizing the control of this new invasive plant.

Emerald ash-borer (*Agrilis planipennis*), a beetle that fatally attacks all species of North American ash trees, was first detected in Maryland in 2003 during routine inspection of nursery stock. Coordinated by MDA with substantial participation by DNR, eradication efforts were effectuated during 2003-2006. These efforts were thought to have contained and prevented spread. However, beetles were found outside the quarantine/eradication zone in 2006 and are likely to be spreading, primarily through the movement of firewood. The eradication and control effort thus bought some time but ultimately failed primarily due to uncontrolled transportation of contaminated firewood, inadequate education of the general public and inability to enforce the quarantine.

As the above examples illustrate, Maryland's ability to respond to new invasions could be greatly enhanced if its existing programs for invasive species detection, research, monitoring and eradication had adequate funding and political support.

*Figure 24. Invasive wavyleaf basket grass (*Oplismenus undulatifolius*) covers acres of the forest floor at Patapsco State Park. Photo by Dr. Vanessa Beauchamp, Towson University.*

Management of established invasive species

Biological Controls.

The majority of invasive species that are here today are here to stay. While eradication of invasive species, particularly plants, from specific sites of small acreage is possible, the only hope of reducing widespread populations is to rigorously test, import and release the insects and other organisms that keep those plant species in check in their native regions. Classical biological control involves importing a monophagous (eats only one thing) insect or host-specific disease from an invader's native habitat. Biocontrol agents are typically imported only after extensive testing for host specificity in their native environment, and further testing under laboratory quarantine conditions for several years in the United States. Once the agent is evaluated and recommended for permitted release in the environment, permit holders are required to follow very specific guidelines for biological control agent release and reporting. Once established, a biocontrol agent and its host invader coexist at low population levels that can be tolerated by the invaded ecosystem.

These biological controls will not be a panacea and it cannot be assumed that all of Maryland's invasive species will be subject to biological controls within time frames that we can envision. In their native habitats, most plant species are attacked and therefore controlled by dozens of insects and other animals and pathogens, in addition to facing competition from other plant species. The instances where only one or two biological control agents can make a significant dent in the population of a plant species may not be common.

Nevertheless, there are encouraging signs of success. For three of the 15 most problematic invasive plant species in the mid-Atlantic region: purple loosestrife (*Lythrum salicaria*), mile-a-minute (*Persicaria perfoliata*) and garlic mustard (*Alliaria petiolata*), at least one non-native insect or fungus has been found. Several insect species have been released under permit as biological control agents for purple loosestrife, and since 2007 MDA has been engaged in a biological control program for mile-a-minute weed. (The permit request for garlic mustard biocontrols has not yet been approved.)

Much of Maryland's biological control implementation (that is, the production and distribution of approved agents) has been carried out by MDA's **Plant Protection and Weed Management Section**. Currently the MDA staff dedicated to the biological control effort consists of one full time contractual employee and one supervisor who can devote only about 15% of his time to biological control projects. This is reduced from the 1990s, when the section had a full-time

*Figure 25. The rare West Virginia White butterfly (*Pieris virginiensis*) is attracted to invasive garlic mustard (*Alliaria petiolata*), a botanical cousin of its native host plant, but eggs and larvae do not survive. Photo by Kerrie Kyde.*

scientist and a staff of a half dozen individuals conducting research and implementation of insect and weed biological control projects. The current group of two individuals currently confines its efforts to rearing and releasing weevils *(Rhinoncomimus latipes)* that are approved for control of mile-a-minute weed and monitoring for previously introduced beetles *(Galerucella spp.)* to control purple loosestrife. While these programs are regarded as successful, they require continued monitoring and release over a number of years. Yet funding is at risk on a year-to-year basis, and there are little or no resources for research or additional introductions.

Management of the Overabundance of White-tailed Deer

If given the chance, native plants would in many cases have the ability to withstand competition from invasive plants. But they are not given the chance to compete when they are preferentially consumed by white-tailed deer. Reducing deer abundance "levels the playing field" for native plants in their competition with non-native plants (Rawinski 2008). The problems arising from the over-abundance of deer in Maryland are addressed in detail in a previous section of this Report.

Removal of Established Invasive Plants

There are specific situations of rare, threatened or endangered plant species barely hanging on against the onslaught of invasive plants such as Japanese knotweed. Intensive, focused physical and chemical removal efforts at those sites could save valuable and threatened habitats even where the targeted invasive species is unlikely to be eradicated in the State. With the addition of a few regional stewards, DNR's Wildlife and Heritage Service could undertake such projects, thus making a real difference to the preservation of Maryland's most valuable and threatened native plant communities.

Regulation of Invasive Plant Sales

Unlike some other states, Maryland does not currently regulate the sale or planting of invasive plants other than those classified as agricultural weeds. To begin to remedy this, the General Assembly in 2011 enacted Maryland's Invasive Plants Prevention and Control Law (Annotated Code of Maryland Agriculture Article, 9.5-101). The law established the Invasive Plants Advisory Committee (described above), which was requested to adopt a science-based protocol to be used as a basis for creating a two-tier list of plants known to be invasive in Maryland. Tier 1 plants will be outlawed in the State. Trade and sale of Tier 2 plants will require retailers and landscape contractors to provide point-of-sale labeling regarding invasiveness. The new regulations are to be phased in, with MDA ultimately assuming responsibility for enforcement as part of its regular nursery inspection program. This responsibility would be added to the existing responsibilities of nursery inspectors and would increase the time for inspection of each nursery. If inspections are to continue at the current frequency (already reduced from prior years), additional staff will need to be added.

Public outreach on invasive species

The fight against invasive species is most effective as prevention and early detection, with rapid response when an invasion has just begun. In addition to educating the general public on this issue, volunteers can be trained to monitor natural areas for invasions, and also to help with eradication. This is already happening around the State as a number of counties train volunteer "Weed Warriors" to identify and remove invasive non-native plants. Many volunteer

organizations conduct invasive plant removal programs, often in local parks. It would increase effectiveness to institutionalize this activity by tracking and promoting it at the State level. When early detections of invasive species are made, volunteers and State agencies could be alerted and put to the task of control.

The Texas Master Naturalists serves as a model partnership among federal and state government agencies and nongovernmental organizations, including the Ladybird Johnson Wildflower Center. According to the web site, www.texasinvaders.com,

> "The Invaders of Texas Program is an innovative campaign whereby volunteer "citizen scientists" are trained to detect the arrival and dispersal of invasive species in their own local areas. That information is delivered into a state-wide mapping database and to those who can do something about it. The premise is simple. The more trained eyes watching for invasive species, the better our chances of lessening or avoiding damage to our native landscape. . . . These teams, coordinated by the Wildflower Center, contribute important data to local and national resource managers who will, in turn, coordinate appropriate responses to control the spread of unwanted invaders. The Invaders Program is designed to move the target audience beyond awareness to action on invasive species."

The Invasive Plant Atlas of New England provides another successful example of early detection of plant invaders in natural ecosystems (see http://www.eddmaps.org/ipane/).

To design such a program in Maryland would require coordination among staff at University of Maryland Extension, MDA, and DNR. A funded position at one of the agencies could act as coordinator. One of the Work Group recommendations is that DNR engage further with volunteer programs like Master Naturalists. This could potentially expand to include invasive species programs like that of Texas.

Recommendations to combat the threat of invasions by non-native species

The spread and the establishment of invasive species is altering and destroying Maryland's botanical heritage and natural ecosystems, as well as inflicting major and long-lasting harm to the State's agriculture, human health and economy.

1. **We recommend that resources be allocated and prioritized toward prevention, early detection and rapid response to control newly introduced or discovered invasive species before they have a chance to spread, become entrenched and exorbitantly costly to control.** Some portion of these resources should be designated for mapping invasive species on and adjacent to high priority sites. An emergency response system similar to the Incident Command System and an emergency pool of funds to use for immediate control work should be established.
2. **We recommend that Maryland State agencies continue to participate in the Maryland Invasive Species Council (MISC).** Although an informal organization, MISC is able to function as a coordinating body for emergency response to new invasive species, as a consensus-building organization, and as an information resource.
3. **We recommend increased support of research on and implementation of invasive species biological controls and organism release programs**. The existing program within Maryland Department of Agriculture (MDA) has been significantly cut in recent years and should be restored at least to prior levels.

4. **We recommend increased support of research on the direct and indirect impacts of invasive species on native species and ecosystems**. Research documenting and detailing the characteristics of invasive species and the harm they inflict would greatly assist in planning and funding invasive species control efforts.
5. **We recommend funding for additional ongoing assessments by the Invasive Plant Advisory Committee and for inspections by MDA under Maryland's Invasive Plants Prevention and Control Act**. Currently, funding is only available for one year for assessments of non-native plants likely to be invasive and thus subject to regulation under the law. MDA will ultimately assume responsibility for enforcement as part of its regular nursery inspection program along with the existing responsibilities of nursery inspectors. If inspections are to continue at the current frequency (already reduced from prior years), additional staff will be needed.
6. **We recommend that Maryland citizens be encouraged and provided with incentives to become involved in stewardship of lands adjoining high priority natural areas**. This is to ensure that invasive species are eradicated or reduced to a maintenance level so that they do not serve as sources for reinvasion of targeted conservation areas.
7. **We recommend establishment of a staff position for invasive species education in University of Maryland Extension Service programs including Master Gardeners**. Public awareness, especially among gardeners, is essential to lessen the spread of non-native invasive species.

*Figure 26. Approved biological control agent, black-margined loosestrife beetle, (*Galerucella calmariensis*) quickly begins feeding when released on purple loosestrife (*Lythrum salicaria.*) This invasive plant threatens native wetland plants and wildlife and has impeded the flow of water in irrigation systems. Photo by Kerrie Kyde.*

Challenge: restoration and landscaping practices

SUMMARY: The use of native plants in restoration, landscaping and gardening should be encouraged in order to enhance biodiversity in partial compensation for the loss of natural biodiversity and to avoid spreading non-native invasive species. In the past, invasive plants were widely planted by Maryland State agencies, but the State Highway Administration, Maryland Department of the Environment and many local jurisdictions now recognize the value of using native plants for restoration, roadsides and other situations. Invasive plants continue to be sold in the trade, as addressed in a previous section of this Report. Public outreach on ecological benefits of native plants in the landscape should be encouraged and enhanced.

How restoration and landscaping affect native plant conservation

Restoration and landscaping include a wide range of planting and gardening activities, from roadside planting, restoration of mined areas and wetland mitigation to residential and commercial landscaping.

The effect of restoration activities on native plant habitats varies with the situation. At one extreme is a habitat restoration project whose goal is the literal restoration of a previously existing habitat. Here, the selection of plants should represent the natural community as nearly as possible. Farther along the scale is a typical roadside. Even if the original floral inhabitants of that strip of land were known, they are unlikely to represent good choices for a roadside "landscape," with its safety, engineering and other requirements. The conservation goal here is to minimize harm to nearby natural areas, not to reproduce them. A similar challenge arises with urban landscapes that may have been developed decades ago: the original flora is unknown and the soil and other conditions have drastically changed. Many projects fall somewhere in the middle, with the plant choices dictated by a mix of ecological and practical considerations. For example, abandoned agricultural areas often have altered hydrology and soil nutrient levels, and may be dominated by invasive non-native species. Nevertheless, a kind of restoration is possible by planting and protecting a selection of trees that approximates but does not duplicate the species mix in nearby forests.

Landscaping with native plants cannot replace lost natural areas, but it has the potential to partially alleviate the impacts of the loss. In fact, even modest increases in the native plant cover on suburban properties significantly increase the number and species of breeding birds, including birds of conservation concern. Birds and other animals need insect food to survive, and native insects need native plants to survive. With few exceptions, only insect species that have shared an evolutionary history with a particular plant lineage have developed the physiological adaptations required to cope with the chemicals in their host's leaves. Thus, native trees such as oaks support hundreds of different butterfly and moth species, whereas many non-native trees support few or none (Burghart et al., 2009).

Figure 24. Maryland native cupflower, Silphium perfoliatum*, with eastern tiger swallowtail, (*Papilio glaucus*, dark female). Photo by Rochelle Bartolomei.*

Homeowners often look to landscaping to increase the value of their properties and thus traditional gardening is usually driven by cultural aesthetics rather than ecological considerations. It is common knowledge that a significant proportion of the plant species for wholesale and retail sale in Maryland originated outside North America or in regions of North America distant to Maryland. Many of those non-native plants serve important decorative and utilitarian functions and do so without harm. Some, however, are invasive, meaning that they escape into the wild and may do considerable damage to our native plant and animal communities. In addition, planting any non-native plant, even one that is not invasive, misses an opportunity to enhance the local ecosystem with a native plant that supports birds, butterflies and other animals, and that might partially compensate for the loss and fragmentation of our natural plant and animal habitats.

Non-native plants known to be invasive, e.g., Norway maple (*Acer platanoides*), as well as plants with characteristics likely to result in invasiveness, e.g., Japanese silvergrass (*Miscanthus sinensis*), are commonly sold and planted in Maryland. As described above, new regulations to ban sale of a few invasive plant species and require point-of-sale labeling of others, are in progress. In addition, some nurseries have voluntarily begun to label plants as potentially invasive and to list alternative species, including natives. The native plant industry plays an important role in providing responsibly cultivated plant material for landscaping and restoration. We caution against harvesting native plants from the wild.

Landscaping and gardening choices, by definition, are made with human preferences in mind. In many cases, those preferences can be well served with an appropriately selected Maryland native plant that will also benefit the other animals with which we share our environment.

The role of local genotypes ("ecotypes") and genetic diversity

In revegetation projects, cultivated plants are purchased from growers and seeded or planted at the restoration site. Even if plant species native to Maryland are used for such projects, the plants may not be from local material. For example, seeds may have been collected from a population in Texas and grown in North Carolina before being sold to a Maryland client. Or, they may be native to one region of the state and planted in another (e.g., coastal plain vs. mountains).

It often happens that a particular plant species grows naturally over a wide geographic range, including various different climatic conditions, soil types, and other habitat characteristics. For example, red maple (*Acer rubrum*) is native in much of the eastern United States, but populations in New England may have genetic differences that enable them to survive a colder climate than those from the Carolinas. Thus, "ecotype" is a concept used to describe a sub-population of a species that has adapted to a particular set of environmental conditions, and usually is defined as having been derived from plants growing within a particular geographic area (Lubchenco and Real 1991).

There is concern about the risks of introducing non-local native plants in restoration projects and roadside plantings. The perceived risk is two-fold: the potential negative impact on local populations of the same species; and the possibility that the introduced non-local plants are not well-adapted to the climate and conditions of the restoration site. For this reason, restoration protocol often suggests using plant sources of local provenance or local ecotypes. As will become apparent in the following discussion, further research on the use of local ecotypes is needed and there may be no conclusion that is generalizable across all species and planting situations.

One of the possible threats to local plant populations from the use of non-local genotypes in restoration projects is genetic swamping of local populations (Booth and Jones 2001). If the introduced plants interbreed with local populations, this will affect the genetics of the local population and may even completely "swamp" it so that the local population is effectively converted to the introduced ecotype. If the introduced ecotype is less adapted to the local conditions—for example, if it cannot survive the occasional drought—then this characteristic will have been transferred to the local population, whose long-term survival is then at risk.[4] It should be noted, however, that in cases of species that have been widely planted over a number of years, it may no longer be possible to isolate or even to identify the original local genotype.

Local ecotypes may be better adapted to the climate and conditions of the restoration site than non-local ecotypes (Allen and Meyer 1998). Adaptation to the restoration site is essential for the persistence of the newly planted population over time. The failure of a restoration project due to lack of adaptation by the new plant material may not directly affect nearby natural habitats. However, when restoration projects fail, the sites are likely to become infested with non-native invasive plants that will invade nearby natural areas.

[4] The need to develop safe "transfer zones" for some native plant material has been expressed by state and federal agencies (United States Department of Agriculture and United States Department of the Interior 2002). Transfer zones provide physical boundaries within which ecotypes of species can safely be transferred, without negatively impacting the genetics of plant metapopulations. Several state programs are already in place. For example, the Iowa Ecotype Project was developed to increase the availability of Iowa-origin seed for roadside plantings and prairie reconstructions (Houseal and Smith 2000). Missouri started a local ecotype program with 33 species from two prairie ecozones, based on climate and soil conditions (Erickson and Navarrete-Tindall 2004). Oregon Department of Forestry (2007) developed seed transfer zones for many tree species.

The choice of appropriate plant material is, unfortunately, even more complicated because geographical distance is not always the best indicator of local adaptation. Habitat characteristics may be more important (Hufford and Mazer 2003). That is, source populations from habitats with similar characteristics may be better adapted to the restoration site than closer source populations from different habitats, even if derived from non-local sources (Ahmad and Wainwright 1976; Hufford and Mazer 2003). In addition, the majority of species used in restoration are common species whose original range was much larger than the current range. Historical gene flow of species in those populations likely covered a greater distance than in current, fragmented landscapes. Thus it can be argued that using seed from distant populations may help to restore the historical gene flow of the species, alleviating to some degree the impact of fragmentation (Sambatti and Rice 2006).

In addition to being adapted to a restoration site, plant material utilized in restoration should be genetically diverse (Society for Ecological Restoration International Science and Policy Working Group 2004). Genetic diversity ensures that plants will be able to respond to future events with a broad range of physiological adaptations (Booth and Jones 2001). These future events not only include average environmental fluctuations for the site but also periodic extreme events, like floods or fires. For this reason, some favor the use of plant material derived from wild-collected seed. However, wild-collected does not necessarily mean locally collected. Due to habitat fragmentation and isolation, many plant communities are genetically depauperate. Small, genetically isolated populations may have reduced fitness (Falk et al. 2001). In this case, introducing material from farther away could actually enhance genetic diversity and result in increased fitness.

It is beyond the scope of the Work Group to reach a conclusion on these matters. Contradictory recommendations about planting practices might be inferred from the various sources described above. We simply comment that in all likelihood, the importance of using local ecotypes for revegetation projects like restoration and roadsides depends on the location and conditions at the restoration site, as well as on the species proposed to be used.

State Highway Administration and Department of the Environment Planting Practices

The State Highway Administration (SHA), Maryland Department of the Environment (MDE), and many local jurisdictions recognize the value of using native plants for restoration, roadsides and other situations and the harm from planting invasive non-native plants.

For storm water management, and erosion and sediment control, where both MDE and SHA are involved, the two agencies coordinate with respect to specifications. SHA has developed specifications to align with those of MDE, but in some cases its specifications are more stringent or different than those of MDE. Specifications are approved by MDE before being used on any project.

In general the seed and plant mixes required by SHA and MDE were developed for engineering purposes, so that, for example, the choice may reflect the need to quickly stabilize and/or revegetate exposed soil, or to address safety priorities such as safe site distances and vehicle recovery zones. Most of the Eurasian species used for this purpose have been used extensively in the United States and are ubiquitous. Some regionally sourced native seeds and seed mixes are

available, and some Maryland-sourced seed mixes are also available through regional companies.

State Highway Administration

SHA promotes the use of native species wherever possible. The SHA 'Landscape Design Guide' (Maryland State Highway Administration 2008) stresses the importance of environmentally appropriate landscape design, which promotes the use of native species and naturalized elements. The SHA ''Preferred Plant List' provides designers with recommended species adapted for roadside conditions. It includes a listing of species that are considered native to Maryland. The Preferred Plant List also list species which are prohibited for use on SHA projects because they are invasive or for other reasons.

SHA reforestation and native meadow establishment operations are performed exclusively with native species. Areas where native plants may not be appropriate include the immediate roadside (10-30 ft off the pavement) and intensely managed landscaped beds. The immediate roadside is generally managed in non-native tall fescue (*Festuca arundinacea*) as this is the best choice for durability and the safety goals of managing this portion of the right-of-way. Intensely managed landscaped beds are generally reserved for urban areas or focal points and may include showy non-native species such as Japanese cherry trees (*Prunus serrulata*). These beds are a relatively small component of the SHA landscaping program.

SHA specifications allow for trees, shrubs, and perennials (whether native to Maryland or not) to be produced in and shipped from USDA hardiness zones 5, 6, or 7 throughout the United States. Due to transportation costs, the majority of this material comes from states east of the Mississippi River. Native meadow grass, sedge, and rush seed are collected from native sources (or grown from seed certified to have been collected from) in USDA Hardiness Zones 5b, 6a, 6b and 7a in states east of the Mississippi River. Meadow forb seed is subject to the same origin requirements as grass, sedge and rush seed but is limited to the States of Maryland, Pennsylvania, New York, New Jersey, Delaware, Virginia, West Virginia or North Carolina.

Maryland Department of the Environment

The Maryland Department of the Environment implements several regulatory programs that affect plant establishment and distribution. The programs regulate permanent and temporary activities in erosion and sediment control, tidal and nontidal wetlands, and mining.

Erosion and Sediment Control

MDE oversees erosion and sediment control for State projects and on State lands. Erosion and sediment control occurs under a State authority delegated to local governments with approved programs implemented by local Soil Conservation Districts. MDE standards and specifications for erosion and sediment control were updated in 2011 as part of work group effort including the Natural Resources Conservation Service and Maryland Association of Soil Conservation Districts.[5] These standards and specifications require that soil disturbed by construction, mining, and other activities be revegetated. The standards and specifications include lists of seed mixes that should be applied in different soil stabilization situations. The conservation benefits are two-

[5]http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/SoilErosionandSedimentControl/Pages/Programs/WaterPrograms/SedimentandStormwater/erosionsedimentcontrol/esc_standards.aspx

fold, preserving soil resources and keeping sediments out of waterways. The revised species lists are an improvement from previous lists in that they contain fewer non-native plants, fewer invasive plants, and more Maryland native plants.

Given the recent revision, changes to the standards and specifications would not be anticipated for some years. However, short of an overall review and revision, some recommended adjustments may be possible, for example, to cease using species that are shown to be objectionable if substitutes are available.

Wetlands

MDE regulates activities in tidal and nontidal wetlands, and requires mitigation to replace permanent wetland losses. Requirements for stabilization of eroding tidal shorelines establish a preference for "living shorelines," which create or restore additional vegetated tidal wetlands. Regulations require that at a minimum, 85% of a mitigation site or living shoreline must be dominated by a species composition acceptable to MDE. MDE exercises best professional judgment in determining when invasive species should be managed for removal. New federal criteria for wetland mitigation will be likely to change the maximum threshold of invasive or exotic species coverage to 5% of the mitigation site. MDE requires that all species in the wetland and its 25- or 100-foot buffer must be native to that region of State, and that all species used for permanent or temporary seeding must be native or non-persistent. After mitigation wetlands are established, there is a standard 5-year monitoring requirement, including establishing responsibility for removing exotic and nuisance species.

MDE typically lists the species that should be used for stabilization when nontidal wetlands are temporarily disturbed. The conditions for restoring nontidal wetlands after temporary disturbance include a list of non-persistent species to be used for stabilization of the site while also allowing for the voluntary revegetation of natural wetland species. MDE is currently updating the preferences and best management practices for seeding and stabilization of temporarily disturbed nontidal wetlands.

Mining

MDE implements regulatory programs for extraction of minerals, oil, and gas. Mining includes both surface mining and deep coal mining and reclamation. Native plant species distribution is affected by mining and post-mining reclamation. Post-mining reclamation requires re-vegetation, but the species selection, including the proportion of native species used, is of necessity influenced by the future planned use of the land, as well the condition of the site.

Stormwater Management

Stormwater management is another State requirement implemented by local governments. The "2000 Stormwater Design Manual" encourages native species. An appendix to the manual contains a list of native species suitable for storm water management.

County/Municipal planting guidelines

The control of land use by county and municipal governments includes landscape design and maintenance. Thus, guidelines and lists prepared by local government agencies may dictate the species selection of property owners. Local landscape design guidelines address issues such as security, screening, historic preservation and recreational needs in addition to taking ecological concerns into account. Historically, non-native species have often been preferred because of their

perceived toughness, hardiness and aesthetic benefits. For many decades local government-recommended species lists have included many invasive species such as Norway maple (*Acer platanoides*), Japanese barberry (*Berberis thunbergii*), English ivy (*Hedera helix*), and burning bush (*Euonymus alatus*).

County and municipal governments may look to State policies and guidelines for best management practices, but are also driven by local political and social forces. For example, Japanese barberry, a major invader of Maryland's forests, is used (because of its thorns) to direct traffic and to screen open areas of commercial spaces from windblown trash, and has become a staple for local zoning requirements. The standards of agricultural communities may reflect the fact that, as an industry, agriculture tends toward monocultures and seeks to reduce bordering biodiversity, which in some cases may function as a sink for crop weeds and habitat for certain pests and diseases.

Recently, some local governments have updated their planting guidelines, eliminating many of the most egregious invasive species and adding native species. To a large extent, changes in local planting guidelines result from pressure by educated citizens who provide input to their local government officials. The Work Group recognizes the challenges, such as heat and drought, which urban and suburban locations present. A complete survey of local planting guidelines was beyond the scope of this Report, but we offer two examples where native plants are being recommended: (1) Maryland National Capital Park and Planning Commission requires the use of native plants in addition to non-invasive exotic species in both Montgomery and Prince Georges counties; and (2) Baltimore City states, "Native species provide additional benefits over non-native species. If you are planting more than 3 trees, at least 50 percent should be native."

Public outreach on native landscaping and gardening

There are a number of programs in place that promote the importance of native plants in Maryland and their use in the landscape:

- DNR offers the long-established Wild Acres program to engage the public to plant their gardens for wildlife, including the use of native plants for pollinators. When first established, the program offered to certify residential properties as Wild Acres, with a certificate and sign. Currently the program is web-based offering fact sheets and periodic newsletter. See http://www.dnr.state.md.us/wildlife/Habitat/WildAcres/index.asp
- The Chesapeake Conservation Landscaping Council (CCLC) promotes the use of native plants for conservation landscaping throughout the mid-Atlantic region, including in Maryland. Through conferences, field days, and their web site (www.chesapeakelandscape.org), CCLC educates professionals and the gardening public on best practices.
- Nature centers, arboreta, and State and county government agencies throughout the State educate the public and promote the use of native plants in the landscape and their importance in their native habitats. For example, the Maryland Native Plant Society and the Sierra Club each has a state-wide presence, sponsoring field trips, providing educational publications and a web site. Other nonprofits such as Adkins Arboretum in Caroline County, and county programs such as Jug Bay Wetlands Sanctuary in Anne Arundel County, also engage the public through publications, field trips, and educational events.

- The University of Maryland Extension Master Gardeners are trained volunteers who promote environmental horticulture in 21 counties and Baltimore City. These volunteers receive basic training in ecology and work with the gardening public to promote their message of environmental stewardship. The Master Gardeners offer the Bay-Wise Landscape Management program (BMP). Master Gardeners receive advanced training on BMPs, including the importance of native plants. Upon invitation, they visit home gardens, consulting or certifying landscapes as "Bay-Wise" based on a list of environmentally sound practices.

Recommendations to increase the use of native plants in restoration and landscaping

The use of native plants in restoration, landscaping, and gardening should be encouraged in order to enhance biodiversity in partial compensation for the loss of natural biodiversity, and to avoid spreading non-native invasive species. This includes planting under the auspices of State agencies such as the State Highway Administration (SHA) and Maryland Department of the Environment (MDE).

1. **We recommend continuing coordination among MDE, DNR and SHA with respect to recommended and/or approved plant lists and review of the lists as appropriate for the removal of objectionable species**. Those agencies recognize the value of using native plants where possible for restoration, roadsides, and other situations, and the need to avoid invasive non-native plants.
2. **We recommend supporting programs to encourage landowners to maintain gardens and landscapes for the benefit of native wildlife and to avoid invasive non-native plants.** Although there has been coordinated outreach to landowners, many members of the public remain unaware of the effects—both negative and positive—of private gardens and landscapes on our natural environment. Proactive strategies will be required to address this information gap.
3. **We recommend discussion among MDA, SHA, MDE, and DNR of the potential for an enhanced native plant and seed industry in Maryland**. Based on examples from other states and preliminary research in Maryland, there may be potential for the State, in partnership with industry, to assist in the development of an enhanced native plant and seed industry to serve Maryland customers, potentially benefitting native plant conservation and local business as well as Maryland consumers. It is understood that further development and enhancement of a Maryland-based native plant and seed industry should be industry driven and that additional dedicated funding for State agencies to providing testing, certification, licensing, and other support functions will be required for program creation and development. A possible model is including as Appendix 4.

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Appendices

Appendix 1: Natural Resources Chapter 655 (House Bill 936)

Natural Resources – Maryland Botanical Heritage Workgroup

FOR the purpose of establishing the Maryland Botanical Heritage Workgroup; providing for the composition, chair, and staffing of the Workgroup; prohibiting a member of the Workgroup from receiving certain compensation, but authorizing the reimbursement of certain expenses; requiring the Workgroup to define challenges to, explore opportunities for improving, and make recommendations regarding the preservation of plant species native to the State and region; requiring the Workgroup to report its findings and recommendations to the Governor and the General Assembly on or before a certain date; providing for the termination of this Act; and generally relating to the Maryland Botanical Heritage Workgroup.

SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND, That:

(a) There is a Maryland Botanical Heritage Workgroup.

(b) The Workgroup consists of the following members:

1) one member of the Senate of Maryland, appointed by the President of the Senate;
2) one member of the House of Delegates, appointed by the Speaker of the House;
(3) the Secretary of Agriculture, or the Secretary's designee;
(4) the Secretary of the Environment, or the Secretary's designee;
(5) the Secretary of Natural Resources, or the Secretary's designee;
(6) the Secretary of Transportation, or the Secretary's designee;
(7) the State Botanist;
(8) the State Soil Scientist; and
(9) one member of the Maryland Invasive Species Council, appointed by the Governor.

(c) The Governor may appoint any other individual to the Workgroup at the Governor's discretion.

(d) The Governor shall designate the chair of the Workgroup.

(e) The Department of Natural Resources shall provide staff for the Workgroup.

(f) A member of the Workgroup:

(1) may not receive compensation as a member of the Workgroup; but
(2) is entitled to reimbursement for expenses under the Standard State Travel Regulations, as provided in the State budget.

(g) The Workgroup shall:

(1) define challenges to the preservation of plant species native to the State and region, including:

(i) insufficient prevention or control of biological invasions;
(ii) habitat fragmentation; and
(iii) the lack of data on species loss;

(2) explore opportunities for improving the preservation of native plant species, including:

(i) the incorporation of advances in biology, information systems, social networks, resilient systems theory, marketing, education, and technological innovation;
(ii) the expansion of efforts to provide extension–style support for citizens seeking to be good stewards of botanical heritage; and
(iii) the best examples of botanical conservation programs in other jurisdictions; and

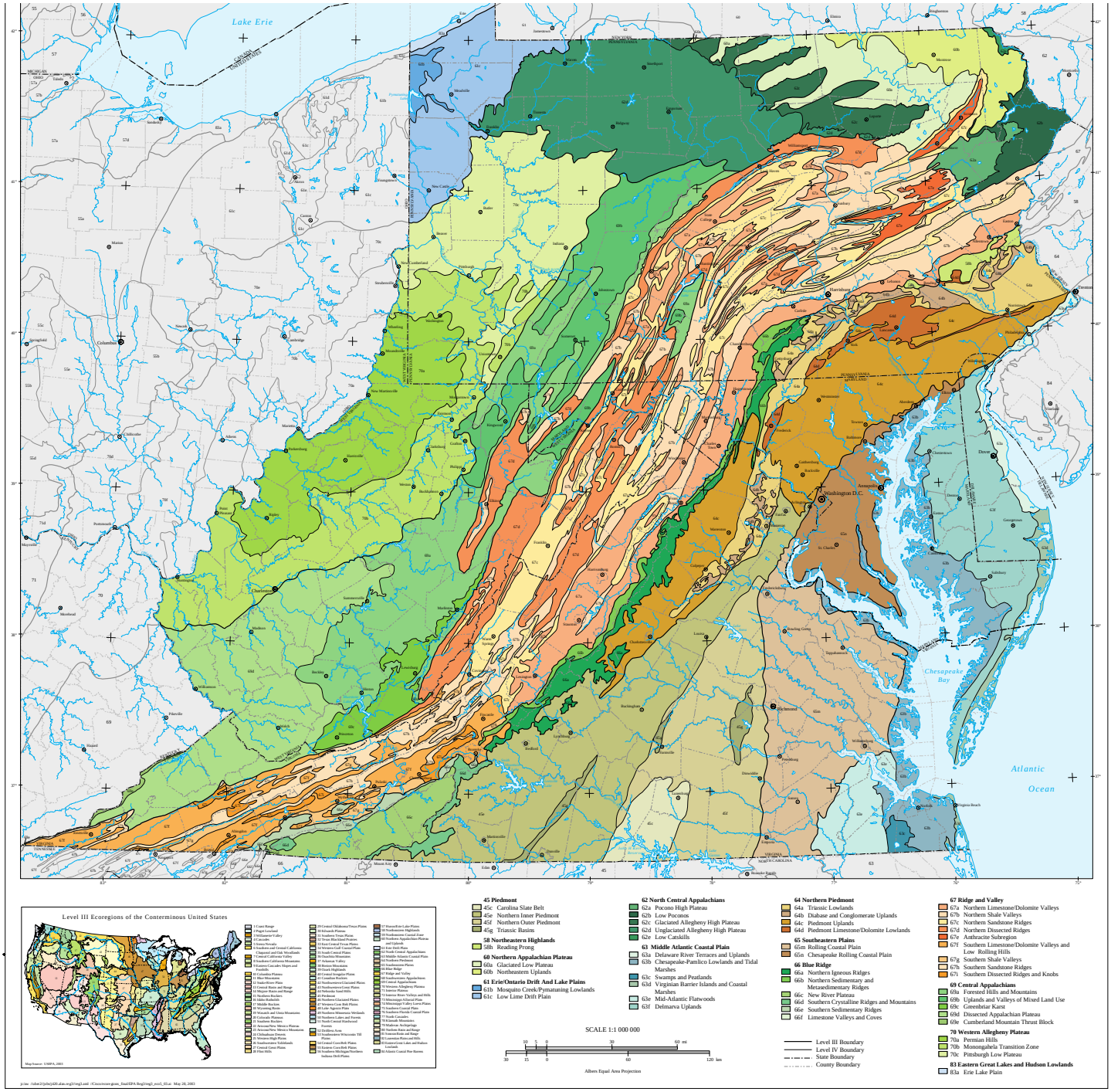
(3) make recommendations regarding the preservation of native plant species, including:

(i) the establishment of botanical conservation goals;
(ii) the collection of conservation data;
(iii) how to address regulatory opportunities and obstacles; and
(iv) how to promote a profitable native plant and seed trade in the State; and
(v) possible sources of revenue to pay for the Workgroup's recommendations.

(h) On or before December 31, 2013, the Workgroup shall report its findings and recommendations to the Governor and, in accordance with § 2–1246 of the State Government Article, the General Assembly.

SECTION 2. AND BE IT FURTHER ENACTED, That this Act shall take effect June 1, 2013. It shall remain effective for a period of 1 year and, at the end of May 31, 2014, with no further action required by the General Assembly, this Act shall be abrogated and of no further force and effect.
Approved by the Governor, May 16, 2013.

Appendix 2: Environmental Protection Agency Level III and IV Ecoregions



Source: http://www.epa.gov/wed/pages/ecoregions/reg3_eco.htm

Appendix 3: Explanation and Key to the Maryland Rare, Threatened and Endangered Plant List

The first line of a typical entry or treatment for a rare plant appears like the example below (this from the revised list due in 2014):

Scientific name	Common Name	Grank	Srank	MDstatus	Federal status
Aeschynomene virginica (L.) BSP	Sensitive Joint-vetch	G2	S1	E	LT

In the above example the species is ranked as globally rare and State rare (G2 and S1 respectively) with a status of threatened at the federal level and endangered in Maryland (states may list a species with a higher but not lower status). However, to understand the terms rank and status as it pertains to States the following examples are presented:

Scientific name	Common Name	Grank	Srank	MDstatus	Federal status
Agalinis skinneriana (Wood) Britt.	Pale False Foxglove	G3G4	S1	E	
OR					
Amelanchier humilis Wiegand	Running Shadbush	G5	S1	T	

From the two examples above we see that State rarity does not necessitate global rarity and it is not necessary to be federally endangered or threatened to have status within individual states. Federal status relates the endangerment of a species within the nation, whereas State status relates the level of endangerment of the species within the State's political boundaries. Each treatment presents the case for rarity in Maryland, i.e., why the rank and status. So, for the above examples it is informative to present the rest of the rare plant treatment instead of just the first line. A key to the headings is presented first:

1. Latin name	Common name	Grank	Srank	MDstatus	Fedstatus

2. Latin Family name (common family name)
3. Taxnote: identifies and clarifies the use of names (taxonomy).
4. Consnote: relates information about the conservation of the species including factors of rarity and threats.
5. CP (PD, RV, AP): abbreviations of physiographic provinces, e.g., coastal plain, piedmont, ridge and valley, Allegheny plateau: Habitat description (counties of occurrence,).

Agalinis skinneriana (Wood) Britt. Pale False Foxglove G3G4 S1 E
Orobanchaceae (Broomrape Family)
Taxnote: Pettingill and Neel (2008) confirmed that Maryland plants were sister to the sample from Missouri but indicate that further investigation may be warranted to determine if the Maryland populations are actually an unrecognized species as our populations are striking disjuncts from the core range in midwestern prairies.
Consnote: Endangered by habitat loss, damage by off-road vehicles, woody succession of barrens habitat.
CP: sandy roads, barrens and fields (Charles, Dorchester, Prince Georges).

Amelanchier humilis Wiegand Running Shadbush G5 S1 T
Rosaceae (Rose Family)
Taxnote: A widespread species in the northeastern U.S. having both diploid and polyploid populations. Maryland populations are near the southern terminus of the species range and some plants were determined to be triploid.
Consnote: Threatened by competition and displacement by non-native, invasive shrubs, particularly *Lonicera maackii*.
RV: outcrops of limestone or other calcium-bearing substrates (Allegany, Washington).

Appendix 4: A Native Plant and Seed Industry Model

This appendix contains a summary description of a model, developed by Dr. Sara Tangren, for an enhanced, locally based, native plant and seed industry.

The intent is to provide a basis for further exploration of what might be developed with State agency and industry cooperation. The three primary systems are based on the USDA's Specialty Crop Industry Model (Bewick 2007). Information specific to the native plant/seed industry was taken from interviews by Dr. Tangren with industry stakeholders in Maryland, Pennsylvania, Connecticut, Iowa, Minnesota and Florida. The model was presented at three stakeholder conferences in 2013 and its content evolves as stakeholder input is received. The accompanying diagram (Figure 1, Appendix 4) depicts this model.

A robust, local, native plant and seed industry could benefit Maryland's economy and its environment. The production and sale of locally native plants and seeds is an activity inherently suited to local farms, wholesale nurseries, and retail shops. Other states have developed industries that are variations on this model, and Maryland could learn from their experience.[6]

Production begins with a state agency that is responsible for producing small quantities of certified, locally native, foundation seed from wild-collected sources. This is provided to farmers and wholesale growers, along with supporting technical information. Farmers use the foundation seed to produce large quantities of certified seed, enough for large-scale plantings (roadsides, mine reclamations, etc.). Wholesale nurseries could also use certified seed to produce locally native plant materials for other landscaping uses.

State policies and regulations affect the demand for plants and seeds. Maryland agencies currently specify the use of native plant material in various situations, but the plants and seeds may be purchased from states distant to Maryland. If local ecotypes and/or locally produced plant material, certified as described above, were regularly specified, then this would create demand that could only be filled by nurseries offering locally native plant materials.

Purchasers of plants and seeds include consumers purchasing for personal use at retail and landscape companies purchasing for professional use. Retail consumers rely on the labeling of plants on store shelves and this labeling may be misleading. For example, plants may be labeled 'native' when they are native to the United States, but are not native to Maryland. Also, some of the plants labeled 'native' are breeder-developed cultivars rather than naturally occurring genotypes, and this distinction may not be apparent to the customer. Moreover, if plants have been produced in a distant region, they may not be well adapted to growing conditions in Maryland. Wholesale nurseries that produce the plants offered by retail nurseries and landscaping companies could benefit from the ability to offer quality, locally produced and accurately labeled, native plants.

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[6] See, e.g., Hodges, A.W. and J.J. Haydu 2006. Economic impacts of the Florida environmental Horticultural Industry in 2005; Fla. Coop. Ext. Serv. Publ. FE675, 40 pp; Houseal, G. 2007. New initiatives in native foundation seed development. Tallgrass Prairie Center Newsletter. Norcini, 2008. Native Plants: An Overview. University of Florida IFAS Extension technical paper ENH1045, 7pp.

Plants of sufficient size and appearance for use in formal landscapes can be hard to source. At the same time, landscapers are experiencing an increase in demand for native plants for use in sustainable landscapes, water-quality plantings, living shorelines, and pollinator gardens.

A well-developed Maryland-based native plant and seed industry could help to meet the needs of many different customers.

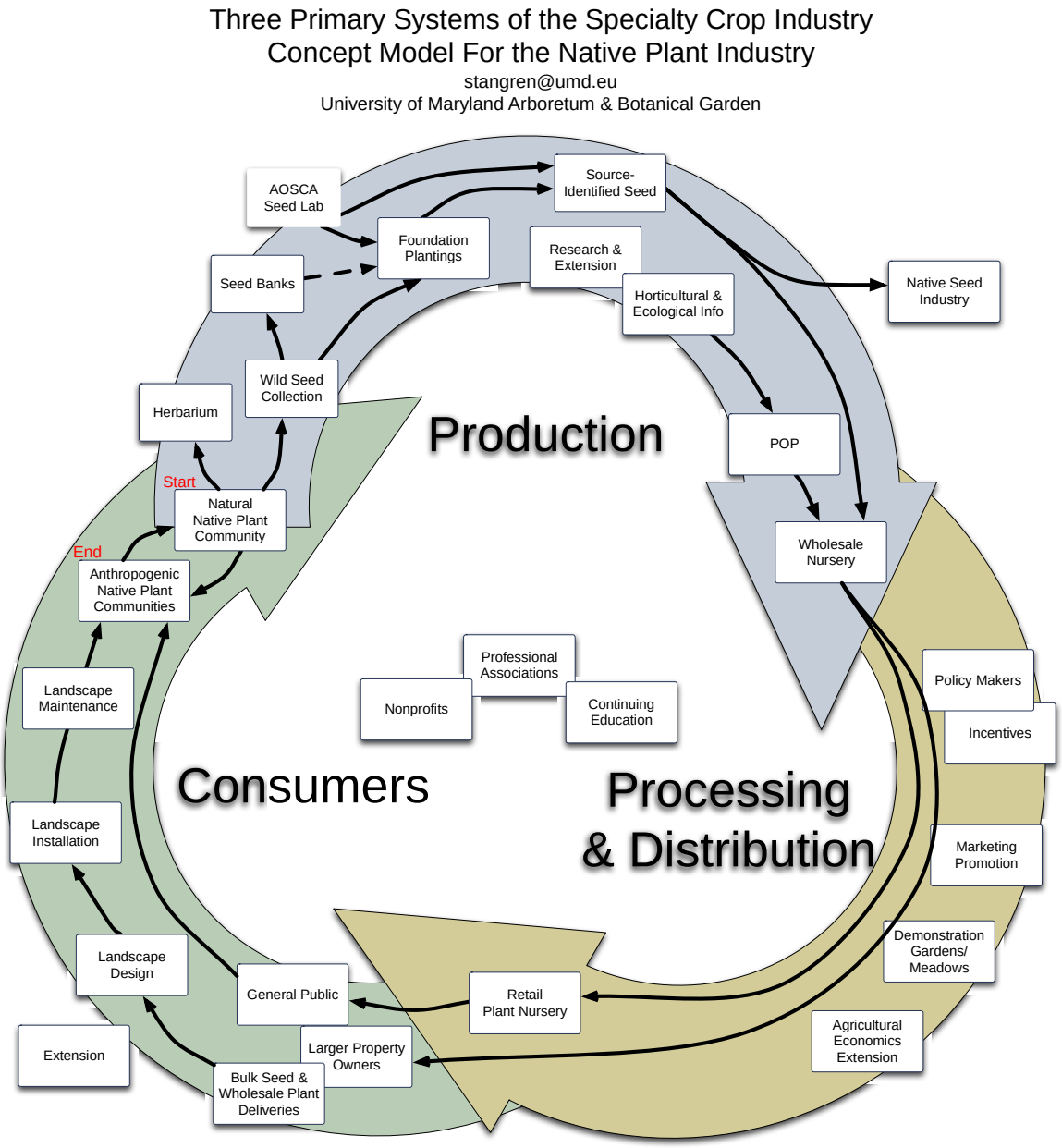

Figure 1 to Appendix 4.