Martin O'Malley, *Governor*
Anthony G. Brown, *Lt. Governor*

State Highway Administration
Maryland Department of Transportation

Beverley K. Swaim-Staley, *Secretary*
Neil J. Pedersen, *Administrator*

STATE HIGHWAY ADMINISTRATION

RESEARCH REPORT

DEVELOPMENT OF NATIVE SEED FOR SHA PROJECTS

REPORT NO. 1: SELECTING APPROPRIATE SPECIES AND WILD COLLECTING THEIR SEED

SARA A. TANGREN, PH.D
CHRISTOPHER F. PUTTOCK, PH.D

CHESAPEAKE NATIVES, INC.

PREPARED IN COORDINATION WITH MR. SHAWN BELT
STEVEN A. BERG, NATIONAL PLANT MATERIALS CENTER, NRCS, USDA

Project number SP608B4K
FINAL REPORT

December 2009

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
MD-09-SP608B4K		

4. Title and Subtitle	5. Report Date
Development of Native Seed for Soil Stabilization	September, 2009
	6. Performing Organization Code

7. Author/s	8. Performing Organization Report No.
Tangren, Sara A. and Christopher F. Puttock	

9. Performing Organization Name and Address	10. Work Unit No.
Chesapeake Natives, Inc. P.O. Box 866 College Park, MD, 20741	11. Contract or Grant No. SP608B4K

12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
Maryland State Highway Administration Office of Policy & Research 707 North Calvert Street Baltimore MD 21202	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The highly disturbed soils that SHA must revegetate are diverse, tough environments for plant life. The chances that some of the seed purchased will be well adapted to a particular stabilization site are optimized if that seed originated from a genetically diverse local collection. The use of locally native seed also preserves Maryland's natural heritage and supports local agriculture. Our goal is to make such seed more affordable and more available to SHA. In this report we develop a quantitative, non-arbitrary process for reviewing species being considered for use in roadside soil stabilization projects: the Attributes review process. The Attributes are 14 plant characteristics that must be understood to decide whether or not a plant is suitable for roadside use. Using this process, a panel of experts selected 3 species: gray goldenrod, beaked panicgrass, and Virginia wildrye, for further development. Gray goldenrod is a short, showy, drought-tolerant flower. Beaked panicgrass is a three-foot tall, warm season grass. Virginia wildrye is a three-foot tall, showy, cool season grass. Seed of each species was wild collected using methods that maximize the capture of genetic diversity. NPMC staff helped the authors to establish breeder blocks. Seed from the blocks will be certified as source-identified by the MDA and Maryland farmers have commenced seed production. A tremendous amount of relevant data was generated for each of the three species (Attributes, wild populations, breeder block establishment, field production work, 2008 harvest weights) and these are presented in supplemental reports. If the project is continued, the supplemental reports will be updated.

17. Key Words	18. Distribution Statement: No restrictions
Native plant, seed, soil stabilization, beaked panicgrass, Virginia wildrye, gray goldenrod	This document is available from the Research Division upon request.

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. Of Pages	22. Price
None	None	41	

Form DOT F 1700.7 (8-72) Reproduction of form and completed page is authorized.

Table of Contents

List of Figures

List of Tables

Acknowledgements

We thank the Maryland Native Plant Society for their participation in selecting appropriate species and locating parent populations, especially Mr. Joe Metzger and Dr. Marc Imlay; the University of Maryland for donating the greenhouse and other space that was essential to the germination research phase of our work (especially Dr. Dick Weismiller, Dr. Frank Coale, Dr. Bill Kenworthy, and Ms. Betty Morgavan); the USDA NRCS National Plant Materials Center staff in Beltsville for the use of space and their time and expertise with the test and production plots, especially Mr. Shawn Belt; the National Tree Seed Testing Lab for advice on seed cleaning and germination research, especially Mr. Victor Vankus; our project farmers (the White and the Plutschak families) for their willingness and enthusiasm; Behnkes' Nurseries for the use of sowing machine, especially Mr. John Peter Thompson and Mr. Larry Hurley; Volunteer Maryland for their support and our volunteer coordinator (Mr. Andrew Clark) for spending a year of his youth with Americorps; and a special thanks to the volunteers from Chesapeake Natives, Inc., and many other organizations who spent thousands of hours weeding, harvesting, and seed cleaning.. A debt of gratitude is owed to each member of the Advisory Committee for giving so freely of their time and knowledge. A special thanks to our project contact at SHA, Mr. Bill Klingelhofer, for his valuable guidance and hard work. Matching funds for this project were received from the USDA Conservation Innovation Grant Program (68-3A75-6-137), the National Fish and Wildlife Foundation (#2006-0094-016), and the Maryland Native Plant Society.

Executive Summary

The goal of this project was to make locally native seed more affordable and readily available to the State Highway Administration (SHA). Locally native seed is an excellent choice for soil stabilization projects, and its use preserves Maryland's natural heritage and supports local agriculture.

CNI assembled experts from local nonprofits, government agencies, and academia to form a Species Advisory Panel (SAP). This panel developed a list of 14 Attributes that should be assessed for any species being considered for use in roadside soil stabilization projects. This report provides guidance and examples for using the 14 Attributes.

From a list of 30 native species that are commonly observed in Maryland meadows, the SAP selected the 10 most promising candidates. After surveying wild populations across the state, three species were selected: gray goldenrod, beaked panicgrass, and Virginia wildrye. The National Plant Materials Center (NPMC), one of the SAP members, worked with us to establish breeder blocks of the selected species. Seed from the blocks is being certified as source-identified and made available to Maryland farmers for seed production.

Seed was collected from Maryland wild populations in the fall of 2006. The highly disturbed soils that SHA must revegetate are particularly diverse and tough environments for plant life. To ensure that the seed in any consignment will contain sufficient diversity to adapt to such wide-ranging conditions, we collected from many parent populations. The wild collection methods were tailored to ensure that we captured both diversity within populations and diversity among populations of the three target species. These three species are discussed further in the 2nd, 3rd and 4th reports of this series.

We recommend that the SHA continue working with the Species Advisory Panel and the Attributes process for reviewing species to be used on roadsides. SHA should continue working with the NPMC to add new locally native stock to the breeder blocks to become certified as source-identified seed for increase by Maryland farmers.

1 Introduction

In this report the authors (CNI) discuss research on soil stabilization plantings conducted with the Landscape Operations Division of the Maryland State Highway Administration (SHA). In CNIs project work plan, we described four project phases:

- Species Selection Phase conducted in 2006
- Wild Collection Phase conducted in 2006
- Germination Phase conducted from 2007 to 2008
- Production Trial Phase conducted from 2007 to 2009

This report covers the first two phases, Species Selection and Wild Collection. The subsequent phases are covered in the 2nd, 3rd and 4th reports of this series, and are discussed in the context of the species that ultimately advanced to the Germination and Production Trials: Virginia wildrye, beaked panicgrass, and gray goldenrod, respectively.

Most of our readers will not be familiar with the environmental components of SHAs mission, or familiar with its relationship to the specific components of this project. Therefore, throughout these reports, we will touch back upon the SHA mission statement (Table 1) and discuss how it relates to our findings.

Table 1: SHAs Environmental Components

1) Efficiently provide mobility for our customers
2) through a safe,
3) well-maintained
4) and attractive highway system
5) that enhances Maryland's communities,
6) economy
7) and environment.

This project supports SHA Objective to develop and maintain Maryland state highways in an environmentally responsible manner, to stabilize soils and prevent erosion that would ultimately pollute waterways, to control the spread of invasive plants on its right of ways and to beautify the highway system by planting more meadows.

SHA contractors stabilize soils by establishing vegetation, usually by sowing seed. Individual areas of soil disturbance can be small or large (as with new highway construction), but the cumulative annual impact ranges from hundreds to thousands of acres.

To date there have been no precise estimates of how much local native seed would need to be produced to meet the demand for roadside revegetation projects along Maryland's 30,494 miles (49,075km) of government-maintained roadways (USDOT 2000). William Klingelhofer[1] has estimated that thousands of pounds of seed are required to sustain roadside revegetation across the State each year. Another estimate of the potential demand for native seed in Maryland can be taken from a study conducted in Minnesota, where a producer survey estimated that 127,000 pounds (57,600kg) of native grass and wildflower seed were produced in 1991, and that the market was growing at an annual rate of 20 to 30% (Dale 1993). Yet, the only seed currently available to SHA in such large quantities or at affordable prices (a few dollars per pound) are unattractive, aggressive, alien species.

SHA is at an impasse: it cannot stabilize soils affordably and use local Maryland native seed. It is the goal of this current project to make affordable, locally grown, locally native wildflower and grass seed available for soil stabilization requirements in Maryland. By so doing, SHA will better fulfill its mission in beautifying Maryland's roads and protecting our environment (Table 2: 4, 7). SHA will also be supporting local agriculture by developing alternative crops for Maryland farmers (Table 2: 6).

[1] William Klingelhofer, Landscape Operations Division, Maryland State Highway Administration 2005. Personal communication.

2 Literature Review

2.1 The History of Stabilizing Soil with Alien Plants

The importance of revegetating disturbed soils (soil stabilization) became apparent during the dustbowl era of the 1920s and 1930s. In 1933, the United States Department of Agriculture (USDA) established the Soil Conservation Service (now the Natural Resources Conservation Service) to change the common agricultural practices that led to the loss of so much of the nation's topsoil. Since then the USDA has been searching the globe for fast growing, rapidly spreading plant species whose foliage and root systems reduce soil erosion. Once found, a species is normally selected for desirable qualities for several generations until an improved and clearly distinguishable form (a cultivar) of the species can be released to the public. Multiple testing trials ensure that the cultivar's distinguishing traits are heritable, i.e., the cultivar is reliably genetically different from the wild stock, and that the cultivar is even more vigorous and fertile than its wild ancestors.[2]

One of the earliest examples of plants promoted for erosion control in the United States is kudzu (*Pueraria montana* var. *lobata*), introduced from Japan in the 1890s and promoted for use by the USDA Plant Introduction Service (Mack 1991). Other examples include Russian olive (*Elaeagnus angustifolia*), quackgrass (*Elytrigia repens* [= *Elymus repens*]), sericea or Chinese lespedeza (*Lespedeza cuneata*), multiflora rose (*Rosa multiflora*), Japanese bristlegrass or giant foxtail (*Setaria faberi*), and the now infamous tamarisk or salt cedars (*Tamarix* spp.) (Reichard & White 2001; Zheng *et al.* 2004, 2005). In 1998, Booze-Daniels *et al.* provided the following statement about the alien species used to stabilize soils in Virginia. "The current list of species that are suitable to roadside use in Virginia is brief. The tall and fine fescues (*Festuca arundinacea* [= *Schedonorus phoenix*], *F. ovina, F. longifolia* [= *F. brevipila*], *F. rubra*, *F. rubra* ssp. *commutata* [= ssp. *fallax*]), bermudagrass (*Cynodon dactylon*), weeping lovegrass (*Eragrostis curvula*), birdsfoot trefoil (*Lotus corniculatus*), and crown vetch (*Coronilla varia* [= *Securigera varia*])".

Even now, most forage, turf, and conservation plantings in the United States consist of fertile, introduced grasses, such as tall fescue (*Schedonorus phoenix*) and smooth brome (*Bromis inermis*) (Vogel *et al.* 2006). One good example of a problematic alien currently commonly applied in soil stabilization projects (Maryland SHA 2008) is sericea lespedeza. In contrast to SHAs mission, this species is not attractive, it is produced out of state[3] so it doesn't support the local economy, and although it helps to stabilize soil, it is otherwise a poor choice for our environment (Table 1: 4, 6, 7). However, it stabilizes soils, and its seed is affordable and available in very large quantities. As pointed out in

[2] This is a discussion of history. With time, the USDA evolved to work on developing cultivars of native species, and more recently has moved toward development of source-identified releases. The change over time can be seen in a list published by the NPMC (Davis *et al.* 2002).
[3] Lois Capshaw, Manager of Seed Testing Lab, Maryland Department of Agriculture. 2005. Personal communication.

the white paper by Beck *et al.* (2008), introduced species are only considered invasive once society determines that the harm caused by them outweighs the benefit derived. Groups around the country are reaching the conclusion that the costs of using sericea lespedeza does indeed outweigh the benefits, as indicated by its inclusion on numerous state invasive species lists (plants.usda.gov/java/profile?symbol=LECU). The North Carolina Department of Transportation, for example, has recommended discontinuing the use of sericea lespedeza. They have placed the species on their "Threat" list (Smith 2008). This is their highest ranking, reserved for species that are a known threat to native habitats and natural areas.

As roads are excellent transportation corridors for people, roadsides are excellent transportation corridors for plants. The spread of exotic plants from roadsides into adjacent habitats has been documented in Florida (Greenberg *et al.* 1997, Jenkins *et al.* 2004), Oregon (Parendes & Jones 2000), Utah (Gelbard & Belnap 2003), and Wisconsin (Watkins *et al.* 2003). Here in Maryland, Mortensen *et al*. (2009) studied the impact of roads on the spread rate of Japanese stiltgrass (*Microstegium vimineum*). They found that the natural dispersal rate of stiltgrass is 1 to 2 meters per year, whereas along roadsides stiltgrass had spread 100 to 200 times more rapidly. They believe that roadside maintenance practices and water transportation in roadside ditches are responsible. It would appear that of all the places to introduce a fertile alien plant, roadsides might be the worst.

2.2 Choosing to Revegetate with Local Natives

By the 1960s, the beautiful grasses and flowers that once represented our nation's unique character were limited to tiny remnants along railways and in graveyards (Gustafson *et al.* 2005). In the Mid-Western states, agriculture has reduced the American prairie to less than one percent of its original area (Noss 1999). Closer to home, estimates of native grasslands lost in Pennsylvania are even more dramatic (Latham 2006). Long before scientists were publishing studies proving that roadways are transportation corridors for plant material, Mrs. Ladybird Johnson was promoting roadside revegetation projects as ideal opportunities to beautify America and reintroduce native wildflowers (Highway Beautification Act 1965; Johnson & Lees 1993; Koman 2001; Gould 2000), thus restoring ecological integrity and indigenous character to an area. As regards to the beautification movement and highway legislation, Mrs. Johnson once said, "I have always been a natural tourist … Wherever I go in America, I like it when the land speaks its own language in its own regional accent" (Johnson & Lees 1993).

It is not merely our grassland heritage and our beautiful wildflowers that are at stake. The very web of life is affected by our landscaping choices. To understand how this could be true, we must for a moment leave our focus on plants as agents for soil stabilization and think instead of their role in the food chain. Plants convert carbon dioxide, water and sunlight into living tissue. All other forms of life (animals, fungi, bacteria, etc.) in the web either eat plants or something that ate plants. In this way carbon and energy are transferred from plants to animals. Tallamy (2007) points out that the main channel for energy from the sun is through plants to herbivorous insects. Examples of just a few categories of herbivorous insects are caterpillars, some beetles, aphids,

spittlebugs and grasshoppers. Once converted to insect tissue, the carbon and energy become available to predators. It is this conversion of sunlight to plants to insects that drives the entire web of life responsible for the populations of butterflies, birds, and wildlife that are such an integral component of Maryland's unique aesthetic (Table 1: 4), recreational economy (6)[4], and environment (7). For example, the young of every songbird species depend strictly on insects for food.

So where is the problem? Tallamy (2007) has shown that herbivorous insects in the Mid-Atlantic region mostly eat native vegetation. In Maryland, much of our native vegetation has been replaced by urbanization and agriculture. Even where wild plants remain, one in every four species encountered is alien (777 of 3,069)[5]. One consequence will be fewer songbirds. Anything that makes it more difficult for parent birds to collect insects to feed their young directly reduces the number of songbirds. So much native vegetation has been replaced by development and by the spread of invasive species that Tallamy states "When extinction adjusts the number of species to the land area that remains for the plants, mammals, reptiles, birds, and invertebrates of North America (something that will happen within the lifetimes of most of us), we will have lost 95% of the species that greeted the Pilgrims."

As a result of the Highway Beautification Act, a new era in roadside revegetation was underway, and many Mid-Western companies began producing native seed to meet highway project demands. As the first few states turned to the use of native species for roadside revegetation, they found that native plants perform better than aliens. It has even been shown that locally native (often referred to as local ecotype) seed outperforms seed of the same species from a distant origin (see for example the comparison of Texas vs. Florida ecotype *Rudbeckia hirta* for Florida roadsides, Norcini 1998; Henderson 2002; McKay *et al.* 2005; Schmidtling 2001; Tangren - unpublished observations). In an overview of the biological principles surrounding plant selection for re-vegetation, Linhart (1995) states that "if there is revegetation to be done, the very worst option is to use seeds (of the same species) from very far away, even if the seeds come from a similar environment, because if the non-native plants would grow to reproduce, they would introduce new alleles and therefore new features (growth form, flowering phenology, breeding system) into the local populations of the same species. "Gustafson *et al*. (2004) found non-local and cultivar seed sources to be so genetically different from the local seed that they cautioned, "Translocating non-local seed in order to increase diversity, or using cultivars, is likely to alter the genetic structure of remnant populations and potentially influence the associated community and affect ecosystem structure and function in unforeseen ways."

---

[4] The following 2006 statistics are from Carver (2009): 19% of Maryland residents consider themselves to be bird watchers. Of all the people who watched birds in Maryland, 16% were tourists. Nationwide, birders spent $36 billion on travel and equipment, generating 671,000 jobs and paying $4.4 billion in federal and $6.1 billion in state taxes.

[5] Davdison, L. (2009). Maryland Dept. of Natural Resources. Ms. Davidson obtained these data from various sources, including information provided to the NatureServe database by Dr. John Kartesz.

2.3 The Affordability of Local Ecotype Seed

The USDA Forest Service has found that locally adapted native seed performs so much better for roadside revegetation than any other product, they will collect seed on site a year or more before construction to have it contract grown ("increased") by local farmers to ensure it's availability. In 2004, the Forest Service Regional Seed Increase Contract approach procured locally native seeds ranging from $6 per pound for grasses to $73 per pound for native wildflowers (Landis *et al.* 2005). In this way, the Forest Service secures the large quantities of seed it needs for soil stabilization at affordable prices.

Fortunately for Maryland's roadside vegetation managers, locally native seed can be produced in quantities that are large enough and at prices that are low enough to be practical for standard use in state highway soil stabilization practices. Several jurisdictions have demonstrated this (Dale 1993; Federal Highway Administration 2002; Wildflower Seed And Plant Growers Association, Inc. 2005; Landis *et al.* 2005). In Florida and Iowa, for example, this has been accomplished through a coalition of academia, agriculture, and the state department of transportation. These coalitions have provided growers with local ecotype foundation seed and production technologies on the one hand, while working with their state highway departments to develop applications for the seed such as soil stabilization and aesthetic improvements.

2.4 Deciding which Native Species to Use

Booze-Daniels *et al.* (1998) are proponents of selecting a native species that already has the desired qualities for a particular use, rather than breeding a species to acquire features that it does not naturally possess. For example, if they wanted a short grass, they would pick a species that happened to be short, rather than picking a tall grass and then breeding a short variety through generations of selection.

They used the following eight criteria to determine whether or not they would recommend a native grass species for use in Virginia roadside plantings:

a. The grass is a native of North America.

b. The grass does not exhibit aggressive behavior.

c. The plant is not on the *Invasive Alien Plant Species in Virginia* (Virginia Department of Conservation and Recreation and Virginia Native Plant Society 1997) list.

d. The grass adapts well to drastically disturbed sites.

e. The grass has potential to persist in the roadside environment.

f. The grass performs as well as species currently used on the roadside.

g. The seed is available or has the potential to be available from native grass seed vendors.

h. Cost will not be a determining factor. Even though the cost of some of this seed is expensive at this time, increased demand may eventually drive the price down."

Shortly after Booze-Daniels *et al.* published their list, articles began to appear in the literature that described the error in a. and b. above. For example, Ayres *et al.* (1999) demonstrated that just because a grass is native somewhere on our continent (a) does not make it an environmentally sound choice for introduction elsewhere on the continent. Released from its native range, a plant may become free of the diseases and herbivores that otherwise restrict it, and it can exhibit previously unobserved "aggressive behavior" (b). Our locally native saltmarsh grass, Mid-Atlantic cordgrass (*Spartina alterniflora* L.), has been introduced to the Pacific Coast of North America and to Europe. Even though the species is not aggressive in its native range, when it was introduced outside its native range, it was found to be moderately aggressive. Furthermore, when it cross-pollinated with the cordgrasses native to its new range, Mid-Atlantic cordgrass formed very aggressive hybrids (Ayres *et al.* 1999; National Academy of Sciences 2003). Introducing new genetic material can affect ecosystem structure and function in unforeseen ways (Gustafson 2004).

2.5 Wild Collecting Seed for Increase and Use in Revegetation

The genetic diversity of the seed that farmers will produce for use on Maryland roadsides is set during the Wild Collection Phase of the project. Rogers (2004) warns that mistakes made during wild collection can inadvertently cause genetic erosion during the course of large-scale planting and reseeding activities. The genetic diversity of CNIs initial collections will determine how robust Maryland's soil stabilization seed mix will be, and how well it will adapt to diverse roadside conditions.

Poor collection methods can lead to a genetically skewed breeder block collection. Examples of poor methods include only collecting from one site, a few patches of plants at a site, sites on one type of soil, plants with large seed heads, tall plants with seed heads located at a comfortable height for the collector, short plants because the collector likes them better, and from plants with seeds that ripen early. Plantings founded from a seed collection that lacks adequate genetic diversity can have difficulty thriving and setting seed, a situation called the founder's effect (Rogers 2004).

As the authors discussed in the introduction, SHAs roadside plantings will ultimately contain millions of plants that will exchange genes with every other plant of its kind throughout Maryland. SHA can make sure that this exchange is beneficial to both the wild populations and the roadside populations by using native plants that contain genetic material that is both diverse and representative of our state.

3 Methods

3.1 Method of Species Selection: The Species Advisory Panel

This phase of the project was an opportunity to bring in expert advice from all the stakeholders, and to build a community (Table 1: 5) among diverse organizations. Our coalition was named the Species Advisory Panel (Table 2). Similar to the Booze-Daniels *et al.* approach, our first method was to define a set of qualities we would want in a soil stabilization species.

Table 2: Experts on the Species Advisory Panel (SAP)

Name	Organization
Bill Klingelhofer, Don Cobur, Bruce Knott	Landscape Operations Division, Maryland SHA
Marc Imlay	Maryland Native Plant Society
John Englert, Shawn Belt, R. Jay Ugiansky	USDA NRCS National Plant Materials Center
Sara Tangren	Chesapeake Natives, Inc.
Dick Weismiller	University of Maryland, Dept. Environmental Science & Technology

To develop a list of species suitable for the SAP to review, the lead author provided her observations of native, mesic and xeric meadows across Maryland. From these, a list of 30 typical species was presented (Table 3).

In the course of examining the 30 species, the SAP developed a list of 14 Attributes that should be understood for any species being considered for use in roadside soil stabilization. Using the Attributes to evaluate species is a process, or a method, and as such could be discussed further here in the methods section of the report. However, the 14 Attributes process is a unique result of this project; no review process like it has been published before. Therefore, the Attributes are presented in more detail in the Results section of this report.

A "NO" vote from any panel member resulted in the species being eliminated from consideration. The list was whittled down to ten species. In the hopes that this pilot project would include one species each of a grass, a legume, and a showy flower, representatives of each category were included on the short list.

Table 3: Species Commonly Found in Maryland Meadows

#	Common Name	Scientific Name
1	Broomsedge	*Andropogon virginicus*
2	Common milkweed	*Asclepias syriaca*
3	Butterfly milkweed	*Asclepias tuberosa*
4	Frost aster	*Aster dumosus*
5	Maryland goldenaster	*Chrysopsis mariana*
6	Virginia wildrye	*Elymus virginicus*
7	Purple lovegrass	*Eragrostis spectabilis*
8	Philadelphia fleabane	*Erigeron philadelphicum*
9	Daisy fleabane	*Erigeron strigosus*
10	Blue mistflower	*Eupatorium coelestinum*
11	Virginia strawberry	*Fragaria virginiana*
12	Purple sneezeweed	*Helenium flexuosum*
13	Woodland sunflower	*Helianthus divaricatus*
14	Camphorweed	*Heterotheca subaxillaris*
15	Little barley	*Hordeum pusilum*
16	Round Headed bushclover	*Lespedeza capitata*
17	Intermediate bushclover	*Lespedeza intermedia*
18	Slender bushclover	*Lespedeza virginica*
19	Blue toadflax	*Linaria canadensis*
20	Spotted mint	*Monarda punctata*
21	Beaked panicgrass	*Panicum anceps*
22	Florida paspalum	*Paspalum floridanum*
23	Foxglove beardtongue	*Penstemon digitalis*
24	Narrowleaf mountainmint	*Pycnanthemum tenuifolium*
25	Pasture rose	*Rosa carolina*
26	Lyre-leaved sage	*Salvia lyrata*
27	Little bluestem	*Schizachyrium scoparium*
28	Gray goldenrod	*Solidago nemoralis*
29	Indiangrass	*Sorghastrum nutans*
30	Purpletop	*Tridens flavus*

3.2 Methods of Wild Collection

Gustafson (2004) described the two elements that are pivotal to the wild collection phase of this project. First, from the seed-user's point of view (in our case, the SHA), locally native seed is hard to wild collect. The patches of native grassland that remain are small, scattered, and difficult to find. So users are driven to purchase seed, but on the market they find only non-local seed and non-local cultivars. Gustafson's concern is that the market seed may not have the genetic diversity necessary for project success, and its "introduction may lead to loss of unique local genotypes".

CNIs methods were chosen to facilitate 1) finding the desired species, 2) capturing their genetic diversity in the seed collection, and 3) certifying the origin of the seed.

We began the Wild Collection Phase in search of all 10 species even though our objective for this grant was to produce only three. We assumed (correctly) that as the project progressed other factors would pare our selection down.

3.2.1 Methods to Support Objective 1: Find the Species

To discover the location of meadow remnants in Maryland, specimens held at the Norton Brown Herbarium at the University of Maryland were examined. Records from the Smithsonian's D.C. Flora Database were also queried (collections.nmnh.si.edu/emuwebbotweb/pages/nmnh/bot/DtlQuery.php?collection=dcflora). Information regarding potential Delmarva peninsula populations was obtained from Adkins Arboretum. Professional botanists and members of the Maryland Native Plant Society were interviewed to provide data on the native meadow remnants.

Some species are easier to locate and identify while in flower. Beardtongues bloom in June, lespedezas in July, goldenasters in August, and goldenrods from August to October. Grasses are easier to locate and key out while they are in seed. Similarly, each species had to be wild-collected when the seed was ripe. Species on the short list of ten ripened from July through November. Often a site was visited to discover the seed wasn't quite ripe yet, and had to be revisited a week later for collection. As a result, each parent population was visited many times.

Brown and Brown (1984) was used as the initial taxonomic reference for plant identification, and the Norton Brown Herbarium was used for verification. As our fieldwork began in 2006, plant taxonomists with the Flora of North America project were reclassifying species within the composite and legume plant families. Taxonomic work on the legumes continues at the time of this writing. The primary key used for this report is the Flora of North America (see for example: Freckmann & Lelong 2003 - *Panicum*; Barkworth *et al.* 2006 – *Elymus*; Semple & Cook 2006 - *Solidago*). Nomenclature follows Kartesz and Meacham (1999), Synthesis of the North America Flora. Further specific information on plant taxonomy is given in the results section.

3.2.2 Methods to Support Objective 2: Maximize Diversity for Better Soil Stabilization

Gustafson's second concern was obtaining the genetic diversity that would secure project success while protecting the local environment ("preserving the genetic integrity of local populations").

Seed was collected throughout Maryland, with the exception of the far western counties of Garrett, Allegany and Washington (SHA Region 1, Figure 1). These counties were excluded because of their different climate and soils, indicating the probability that ecotypic adaptations would be significantly different from the rest of the state – in other words, they would constitute a new seed transfer zone. With additional financial resources this project could be expanded into SHA Region 1, and possibly parts of West Virginia and Pennsylvania.

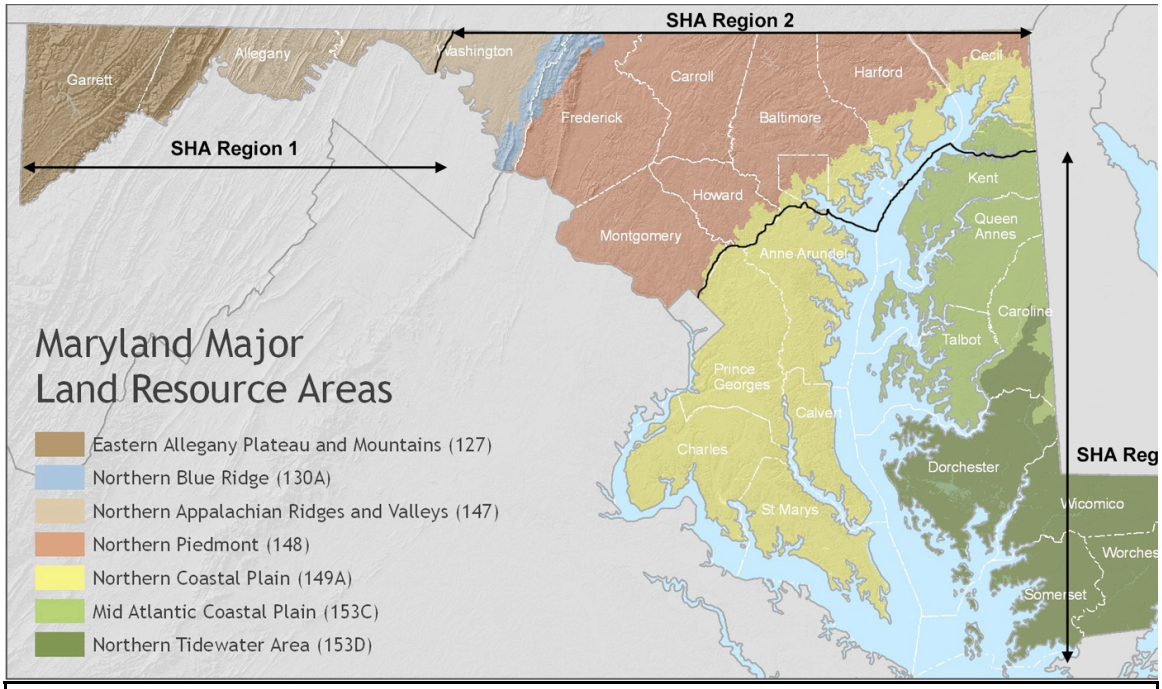

Figure 1: SHA Regions and Geologic Provinces of Maryland (based on Moore 2008).

This is a Maryland map showing the physiographic provinces from the Coastal Plain in the east to the Mountains in the west, and how those provinces relate to the USDAs Major Land Resource Areas. It also shows SHAs management regions, 1 through 3 from west to east.

Within a given species, wild plants contain two types of genetic diversity: that found among individuals within the same population, and that found among populations (Linhart 1995). CNIs goal was to capture both types of diversity in the wild collections. To do this, we followed the seed collection advice outlined by Rogers (2004) and the Bureau of Land Management (2008). For example, we sought 10 to 20 parent populations for each species. Breaking with tradition in a profession where propagules were usually taken from a limited number of individuals with distinctive traits, plant breeders from the USDAs Tucson Plant Materials Center (Munda & Smith 1995) also emphasize the importance of collecting from multiple populations of a species. They note that for highly disturbed desert soils (and SHA typically works on highly disturbed soils), seed from just one population, the closest population, is not necessarily the best-adapted seed for re-vegetation. This is because the disturbed soils may be so dissimilar to nearby natural soils, that one local population may not contain adequate genetic diversity for the plants to adapt to and successfully revegetate the disturbed site. In an overview of the biological principles surrounding plant selection for re-vegetation, Linhart (1995) concurs, stating that "seeds from a few (or many) individuals from one population only will be inadequate."

Species were discarded from consideration if too few parent populations were found, or if parent populations could not be found in both SHA Regions 2 and 3 (Figure 1). We

collected from at least 50 individuals within each population, except in those populations where fewer than 50 individuals occurred[6].

We followed guidelines for ethics in seed collection, for example not taking more than 20% of the seed available on a given visit (Bureau of Land Management 2008), not damaging the surrounding flora, and getting permission from all property owners (Maryland Native Plant Society 2002). In populations with many individuals we collected randomly within each stratum: for example, some from tall plants and some from short, some from the bottom of the hill and some from the top, some from shade and some from sun, etc. This technique is called stratified random sampling. Furthermore, care was taken to acquire approximately the same amount of seed from each plant.

After wild collection, seed was brought back to the University of Maryland Research Greenhouse Complex for germination testing and plug production. The plugs were then moved into seed production plots. The Germination and Production Phases are discussed in the next three reports in this series, organized according to species: Virginia wildrye, beaked panicgrass and gray goldenrod.

3.2.3 Methods to Support Objective 3: Seed Certification

SHA cannot compare the value of seed offered by multiple vendors unless that seed is certified as to its species, origin, purity, and germination rate. Young (1995) states that "verification of genetic origin and purity of these (local ecotype) germplasms is just as important as it is for traditional cultivars". Certification of seed starts years prior to the actual sale, when the original germplasm is wild collected. During the wild collection and production phases of this project, we have worked closely with the Maryland Department of Agriculture (MDA) Seed Testing Lab, which is the local member of the Association of Official Seed Certifying Agencies (AOSCA). The plan has been to follow AOSCAs guidelines for "natural track" germplasm development and receive the Source Identified Class pre-variety germplasm certification for seed produced as a result of this project. On AOSCA's natural track, germplasm accessions are an unrestricted representation of the intact wildland plant population, and genetic manipulation is purposefully avoided during the seed increase process (Young *et al.,* 2003).

So that the wild collection effort could be validated, MDA staff visited each parent population to confirm the presence of the species that we reported. They also visited the breeder blocks at the National Plant Material Center (NPMC) to confirm that those blocks are consistent with the parent populations as claimed. In the future, MDA will also visit the private farms to confirm that the crops being produced appear to be consistent with the breeder blocks. They will also count the number of generations between the wild population and the final product. Too many generations in cultivation can result in a product that is not suitable for roadside use. After germination testing, they will have all the information necessary to issue the desired source identification tags on bags of seed to be sold by the farmers to the SHA.

---

[6] The Bureau of Land Management recommends against collecting from populations with fewer than 50 individuals; They suppose we could choose to collect from a larger population somewhere else. In our project that was not the case.

4 Results & Discussion

4.1 Desired Attributes of Species Used for Roadside Soil Stabilization

In 2006, our Advisory Panel deliberated over the qualities a native plant would need to facilitate successful roadside soil stabilization projects. The Attributes list (Table 4) is the result of those deliberations. It contains some of the same considerations as the aforementioned Booze-Daniels list, albeit in a more specific or refined form. The Attributes fall into four categories: Ecological, Soil Stabilization, Roadside Maintenance, and Affordability/Agriculture.

Table 4: Attributes that Determine Species Suitability for Soil Stabilization Use on Maryland Roadsides.

Ecological Considerations:	
1	Native status
2	Abundance and distribution
3	Ecology, genetics, and taxonomy
Soil Stabilization Considerations:	
4	Special site condition abilities or requirements
5	Germination/sowing requirements
6	Speed of growth
7	Height
8	Winter cover
9	Root structure
Roadside Maintenance Considerations:	
10	Safety and interactions with wildlife
11	Aesthetics
12	Mowing requirements and tolerances
13	Herbicide compatibilities for roadside use
14	Road salt tolerance (for the low mow zone),
Affordability/Agricultural Considerations:	
15	Ease of weed control
16	Abundance of seed
17	Ease of harvest
18	Ease of seed cleaning
19	Shelf life

The development of these lists is the first accomplishment of this project and is a stand-alone result. The entire list can be used to guide future selection of species for seed development efforts. The first three sections can be put to use immediately to evaluate seed (or plant) recommendations made by vendors, contractors, and other government agencies.

Throughout this series of reports, when the authors capitalize the word attribute, it will indicate that we are referring specifically to the Attributes listed by the SAP. In the sections that follow the authors will discuss why the Advisory Panel placed each Attribute on the list.

Then we will discuss the process that SHA or its contractors can use to evaluate each Attribute when considering a seed stock for roadside use. So that SHA staff may conduct a review of any species on their own, or so that they

can judge the quality of reviews provided by contractors, we offer multiple standard references that should be consulted, at a minimum, for determination of each Attribute.

4.1.1 The Ecological Considerations

Reviewing a species' ecological Attributes enables SHA to make plant choices that are in alignment with the seventh component of the SHA mission statement (Table 1), enhancing Maryland's environment.

Attributes 1 & 2: Range, Distribution, and Abundance

A. State Native: The Species Advisory Panel wants reviewers to consider whether or not a plant is native to Maryland. A State Native is any plant that existed in the current boundary of Maryland before the presence of Europeans. It was the consensus of the Advisory Panel that the SHA should target native species for use in roadside stabilization. Performance, conservation of the local flora, and preservation of a local aesthetic are the bases for the recommendation, as discussed in the Introduction. To determine whether a plant species is native, the following references should be consulted:

i. **Shetler and Orli (2000 & 2002)** list species native to the larger Baltimore-Washington area;

ii. **Brown and Brown (1972, 1984)** occasionally indicate whether a plant is native or escaped;

iii. **Metzger (1995)** has compiled the only list of plants native to our State; and

iv. **Experts** familiar with the local flora (for example at the Maryland Native Plant Society).

Ideally all these references should be consulted because occasionally one will be misleading or in error. These references are primarily based upon voucher specimens held in herbaria and by field observations.

B. State Rarity: The Species Advisory Panel wants reviewers to determine how abundant a species is within Maryland, and what its natural distribution within the state is like? One reason is to avoid any undesirable environmental, legal or political consequences of working with state-rare species. Upon first consideration, many readers may think that we should target rare species for roadside use, thus helping to propagate them and spread them around. However, doing so incorrectly could have irreversible genetic consequences for our wild populations and that would be in conflict with SHAs mission statement (Table 1) to enhance Maryland's environment. Doing a good job of using a listed species on roadsides would typically require extensive preparatory research, acquisition of permits, planning and expenditures that SHA may not wish to invest in. The use of seed from out of state, while technically legal, would likely have even more negative ecological consequences than the use of local seed. To determine whether or not a species is rare within Maryland, the reference to consult is Rare, Threatened, and Endangered Plants of Maryland

(Maryland Department of Natural Resources, 2007, available on-line at www.dnr.state.md.us/wildlife/espaa.asp). If a plant is listed, that typically means there are fewer than 15 remaining populations left in our state. In most cases, the consideration of a species should stop once it is found to occur on this list.

C. **State Abundance:** However, we are not just targeting species that aren't rare, we are looking for truly representative Maryland species. If we use a species that occurs in Maryland, but only rarely, or is at the limit of its natural range, we may not get the good roadside performance that we desire, and we lose the opportunity to show off Maryland's own aesthetic. In addition to the reviewer's personal observations on abundance and distribution, the following references should be consulted and reported:

   i. **Brown and Brown (1984):** typically provide comments on a species' abundance, geographic distribution, and the habitats in which it grows.

   ii. **Plant lists at the Maryland Native Plant Society Website:** (www.mdflora.org/plantinfo/plantlists/lists_by_county.html)[7] are a great resource for evaluating Attribute 2.

   iii. **Parks/Government Properties:** sometimes have lists of plants that occur on their grounds. For example, a plant list was published for the Beltsville Agricultural Research Center (Terrell *et al.* 2000). The Center occupies 6,866 acres and the plant list is actually a small book.

   iv. **Marylandica/Maryland Naturalist:** Many Maryland plant lists are available in small society journals. Consequently they are missed by computerized literature searches and overlooked by librarians. But they are immensely valuable for the question of native status and distribution. These small journals are Marylandica (available on-line www.mdflora.org), and the Maryland Naturalist (www.marylandnature.org/stmdnat.htm).

   v. **U.S. Fish and Wildlife Service (Slattery *et al.* 2003):** has published a helpful booklet on garden-worthy plants native to the Chesapeake watershed. It will not include many of the species appropriate for roadside use. We recommend it here with the caveat that it does contain a few errors, and a few state rare species. The best feature for our purposes is that it indicates which geologic provinces a species occurs in naturally: Coastal Plain, Piedmont, and Mountain.

   vi. **University of Maryland Norton Brown Herbarium:** Specimens preserved in herbaria provide an excellent indication of a plant's distribution over time. With over 70,000 specimens, the Norton Brown Herbarium is the premier collection covering Maryland.

   vii. **Smithsonian National Museum of Natural History:** a searchable database of the collection is available online at http://collections.nmnh.si.edu.

D. **Habitat:** To apply a species to roadside projects successfully, we need to know if the species is typically found in particular habitats or ecoregions, or if it is a generalist

[7] The lists at the MNPS website are highly recommended with one exception, Native Plants for Anne Arundel County, which contains a handful of rather significant errors.

species. To vegetate the roadsides of Maryland, with all their diverse conditions of soil, sun, moisture, pH, and salinity, we will need both specialist and generalist species. The references to use for habitat are the same as those for abundance, above.

E. National/International: New resources are making it easier to determine a plant species' broader range.

i. The PLANTS database (www.PLANTS.usda.gov, USDA NRCS, 2006+) has recently added a map toggle that allows the visitor to view both distribution and native range[8]. PLANTS database maps are often available for the multiple varieties or forms of a species, and these tend to be affiliated with particular geographic areas. As you will read in the gray goldenrod results, there can be important differences between a variety native to one part of the country and another. The PLANTS database also typically offers additional links to follow.

ii. Wikipedia (www.wikipedia.org) can be an excellent source for an overview of a species. Pages that are well written offer valuable information about international distribution and recent research. For many species, no page will be available yet. Occasionally there are serious errors or very opinionated pieces because this is not a refereed information source. Double check any pivotal information obtained from this resource.

It is not uncommon for the above references to provide conflicting information. In most cases it is probably best to "keep it simple" and stick to those species that are clearly native according to all authors. However, there are resources to call upon if SHA should wish to resolve such a conflict: any of the authors listed in this section, faculty at local colleges and universities, experts at the Maryland Native Plant Society, Chesapeake Natives, the Smithsonian Institution, and The Nature Conservancy.

Attribute 3: Ecology, Genetics & Taxonomy

Why does the Advisory Panel recommend that we understand the ecological and genetic character of a species before we begin using it on Maryland roadsides? This type of knowledge can be very useful in all stages of our project from the initial species selection and wild collection through to the actual roadside placement and maintenance. Unfortunately, very little such information is available. So you have to take what you can get from the literature for each species, and see how it is (or isn't) relevant to your work. Here are some of the types of relevant things you might learn in studying the literature on a species: how the species is pollinated; whether it tends to self pollinate; whether it tends to hybridize within its genus or family; whether its invasive elsewhere; what types of bacteria, fungi, insects, mammals, birds, etc., are affiliated with it and in what ways; whether there are multiple ploidy levels, forms, varieties, and races within the species and what their geographic distribution is; whether it colonizes disturbed habitats

[8] Caution should be taken however as the improvement is new and the database is huge, there are still occasional errors that will no doubt be worked out in time. Also, even isolated or geographically extreme records of species occurrence can cause the entire state to be colored "native".

or has high fidelity to mature ecosystems; and how it relates to other plants in its habitat (allelopathy for example).

We will see concrete examples of the importance of ecological, genetic and taxonomic information later in this paper. We will discuss the wildryes, which are a product of natural hybridization between species within the wheat tribe of grasses. We will discuss recent taxonomic revisions within the Virginia wildrye complex. We will discuss how introducing alien grasses can lead to the evolution of new, and sometimes invasive, hybrid grasses. We will also discuss the two varieties of gray goldenrod, one west of the Appalachians and one to the east. The western race is a weedy, aggressive tetraploid organism, very unlike our eastern race.

To determine the ecological and genetic Attributes of a species, a good place to start is a thorough review of the species' taxonomy. Taxonomic classifications are changing as DNA analysis rearranges our understandings of plant relationships. An examination of synonymy is also in order, as many species have gone by other names in the past and some literature may only be found if the researcher uses the appropriate synonyms. An excellent starting point for work in Maryland remains the 25 year-old publication by Brown and Brown (1984), however it would be negligent to leave any plant identification at that point now. From there one should proceed to the PLANTS database (www.plants.usda.gov, USDA NRCS 2006+) for synonyms and additional links. The Flora of North America (Flora of North America Editorial Committee, 1993+) is available on line and contains the most current understanding of plant taxonomy for our area. It also provides useful references for further reading.

To obtain the information needed it is necessary to review any available literature on the species. Databases in agriculture, biology, and entomology will often lead the way to relevant literature. Access to these databases can be obtained through government agencies and universities. Some botanical literature is in local journals that are not included in scientific databases. The National Agricultural Library is an excellent resource whose reference technicians will assist in such searches.

As one reviews the collection of literature for a species, it is necessary to keep in mind that results and conclusions reflect the understanding of that species at the time the article was written. Only within the last few years have we become aware of the existence and impact of the race, variety or ploidy level found in plants. Most of these variations are geographic in nature: the further away an author is from Maryland, the more likely he was writing about a different form, race, variety or subspecies of the plant in question.

In reaching out to experts for additional help in understanding or interpreting taxonomic and genetic findings, we have had success in contacting authors directly. Experts at the National Plant Materials Center, the USDA Forest Service, the Maryland Natural Heritage Program (the State Botanist's office), and the National Park Service can often provide needed insights. Because these institutions have different missions, they will sometimes provide opposing points of view, so obtaining several opinions can be quite informative.

4.1.2 The Soil Stabilization Considerations

Many species would be excellent choices for roadside use, but would not necessarily have the special qualities ideal for soil stabilization. Understanding special abilities, germination behaviors, speed of growth, plant height, root structure and winter cover enables us to use a species most effectively. For example, at one of our meetings, Species Advisory Panel member Don Cober stated that understanding germination and speed of growth would allow us to include species that would provide rapid cover in the first years, and species that would provide long term cover and aesthetics in the years that follow.

Attribute 4: Special Site Condition Abilities or Requirements

The Species Advisory Panel recommends an understanding of any special abilities or requirements that a species has. After all, not every species suitable for soil stabilization will be ideal for every stabilization site. Is it limited to certain soil types, exposures, or moisture regimes? Does it have an exceptional drought tolerance, or the ability to grow on south-facing rocky slopes? Often the limitation and the requirement are the same, for example, some plants that have the unusual ability to grow in excessively well-drained sandy soil, can only grow there. Much information on this topic will be revealed in the literature search conducted for previous Attributes. If the National Plant Materials Center has published a Plant Fact Sheet or Plant Fact Guide, relevant information can be found there.

Attribute 5: Germination and Sowing Requirements

The Species Advisory Panel recommends an understanding of the species' germination requirements because most soil stabilization projects use seed. Seed is the most affordable method of introducing thousands, even millions, of propagules to a site – if it germinates. Seed is also easier to store than potted plants or plugs. To succeed with each species, we will need to understand how to store the seed, how the storage impacts seed dormancy and germination rates, how to sow the seed (for example, can it be hydroseeded?), when to sow the seed, and when to expect germination.

To determine the germination and sowing requirements, there are a few books on germination biology to check (Deno 1993; Baskin & Baskin 1998), and some data posted on-line (Native Plant Network and USDA Plants www.plants.usda.gov/). Again, it is imperative to look for relevant literature. For a few species, like gray goldenrod, extensive literature on germination biology is available. Occasionally you can find someone who has personal experience working with the seed and who is willing to share what they have learned.

Attributes 6 & 7: Growth and Height

The Advisory Panel recommends understanding growth rate and height because these two Attributes determine how the plant will be used in soil stabilization mixes. Species that germinate quickly and then grow quickly are desirable for soil stabilization. Not all species in the mix need to grow quickly. In fact, the Panel expressed a specific interest in more slow growing species that might mature into the site and improve function and aesthetics with time. However, at least some of the species in the mix need to demonstrate rapid growth and good vigor.

Tall species are desirable in some roadside applications like windbreaks, snow breaks, and visual screens. However, placed incorrectly they can obscure motorists' view of merging traffic. Short species are desirable for maintaining lines of sight, and adjacent to shoulders where motorists may need to walk if they have to pull over.

Determining speed of growth is difficult. The information is typically only available if the species has been used in some horticultural setting, in which case it may be found in gardening books and magazines, or by talking with staff at the NPMC, a botanic garden, or the MNP*S*. Determining height is easy. The height in Brown and Brown (1984) will typically reflect what you will find in wild settings or roadside plantings. Gardeners and gardening references may give you slightly greater heights because native plants tend to grow bigger in formal gardens.

Attributes 8 & 9: Winter Cover and Root Structure

The Species Advisory Panel recommends an understanding of a species' roots and leaves because these are the working parts that actually stabilize soil. A plant's leaves and stems cover the soil surface and intercept raindrops. When a raindrop hits bare soil, the kinetic energy of the raindrop is transferred from the drop into dislodging soil particles. If that raindrop is intercepted by a leaf or stem, the soil is protected. All plants provide some cover for the soil during the growing season. In the fall, some herbaceous plants wither away completely, not to be seen again until spring. Many turn brown, but retain their vegetation into spring. Brown vegetation is as effective at intercepting raindrops as green vegetation. A few native plants retain some green growth during winter (Figure 2). It is not necessary that every plant in a soil stabilization mix offer winter cover, but it is necessary that the mix should contain several species that offer this benefit.

Figure 2: Early April Foliage and Roots on Gray Goldenrod.

This photograph shows the gray goldenrod plant being dug from the field. Basal foliage rosette is green and full. Root mat is fibrous and large.

As anyone who has weeded a garden knows, there are a diversity of root structures that occupy different underground niches, and all are important components of a sustainable meadow. Gray goldenrod, for example, has a robust fibrous root mat that anchors the top few inches of soil (Figure 2) very well. Some plants have a taproot, which acts more like a spike, anchoring the topsoil to the subsoil, and cycling nutrients up from several feet below. Butterfly milkweed (*Asclepias tuberosa*), horseflyweed or wild false indigo (*Baptisia tinctoria*) and shrubby lespedeza (*Lespedeza intermedia* = *L. fructescens*) are examples of native plants with taproots. Several native plants have rhizomes, commonly referred to as runners. Rhizomes not only allow a plant to spread quickly and form vegetative colonies, they also form great subterranean bands, literally strapping the ground into place. The Panel has added Attribute 9 – root structure – so that designers of stabilization mixes will remember to include a diversity of root structures.

Another important factor to understand about a species' roots are the micro-organismal relationships. Some species' roots have symbiotic relationships with mycorrhizae. The plant gains an extended system for collecting water and nutrients from a larger volume of soil. The fungus gains sugars produced through photosynthesis. And we benefit, too, because soils with healthy microorganism communities gain a crumb-like soil texture that reduces soil erosion. Typically, disturbance-adapted plants do not have mycorrhizal symbiosis. Plant species that have a high degree of fidelity to mature ecosystems are likely to have some micro-organismal affiliations. In most mesic soils, even those that have been disturbed, the appropriate microorganisms are present and will flourish when their symbionts are planted. A lack of soil microorganisms can be responsible for planting failure in excessively well-drained soils (Miller 1997).

A plant's root structure can usually be determined by reference to Brown and Brown (1984). Root structure can also be determined by speaking with nursery production staff, gardeners, or by digging up a plant.

4.1.3 The Roadside Maintenance Considerations

A combination of special conditions, needs, and maintenance procedures make highway roadsides a unique environment for growing plants. Some of these conditions are:

- Constructed and compacted soils,

- Cut slopes,
- Lines of sight and corresponding vegetation heights that provide safety for motorists, pedestrians and wildlife,
- Obstructed lines of sight to minimize headlight glare,
- Vegetation that deters wildlife from being near the road in the first place,
- Vehicle exhaust that impacts plant communities,
- Melt water from de-icing chemicals.

Many of the species we would otherwise nominate will not be compatible with roadside conditions and maintenance procedures. We must have any available knowledge as to how our candidate species will respond.

Attribute 10: Safety and Interactions with Wildlife

Plants that offer good opportunities to watch wildlife are unsafe choices for the roadside. (see Table 1). This is why woodland sunflower (*Helianthus divaricatus*) and common milkweed (*Asclepias syriaca*) were quickly eliminated from consideration despite other highly desirable qualities. Many drivers will instinctively brake or swerve to avoid obliterating a beautiful animal, and both people and wildlife can suffer from these interactions.

Gardening books are often written with an eye toward attracting birds and large butterflies, so they are a great resource for determining which animals visit various plants. Gardening books also tend to mention which native plant species are least desirable to rabbits and deer.

On the other hand, all native plants provide some support for wildlife and this is part of why we are trying to preserve them. They are the basis of the food chain that supports all of the wildlife we hope to pass on to future generations of Marylanders (Tallamy, 2007). What is the happy medium? Many native plants do not draw noticeable numbers of the big vertebrate herbivores, but they do attract the tiny, invertebrate herbivores – insects like aphids, crickets, and mealybugs that are not traffic hazards. Through careful consideration, we can select these plants for close proximity to roadsides, and save great bird watching plants like woodland sunflower for our rest stops.

Attribute 11: Aesthetics

The Advisory Panel recommends that we understand the aesthetic qualities of each species considered for roadside use. This is not to suggest that every species in a stabilization mix have tremendous aesthetic value, but certainly none should be unsightly. Horseweed (*Conyza canadensis*) is an example of a plant that is so unattractive it would probably be disqualified from consideration. The tall fescue and sericea lespedeza currently in common use are quite plain. Maintaining the roadside in an aesthetic manner is part of the SHA mission statement (Table 1), so at least some of the species included in a stabilization mix should beautify the roadway.

To determine aesthetic qualities, a quick internet search should reveal images of most species. Since we are working with abundant and representative species (Table 4, Attribure 2) it should not be too difficult to locate some wild plants to observe personally during the course of a few seasons.

Attribute 12: Mowing Requirements and Tolerances

The Advisory Panel recommends a familiarity with the mowing requirements and tolerances of any species to be used along the roadsides. The area immediately adjacent to the road shoulder is referred to as the "low mow zone". The mowed area beyond this is referred to as the "high mow zone". Vegetation beyond the high mow zone typically is not managed, except occasionally to eradicate noxious weeds. To understand the placement of the proposed species within these zones, it will be necessary to understand how they respond to periodic mowing.

For most species it is very difficult to determine mowing tolerances. There is very little information on the topic in the literature, and gardeners don't mow their plants, so the information is not present in gardening books. One technique the authors have had success with is to visit roadsides where the plants occur, and observe how they respond to the mowing regimen there. Given time, one could find or plant and then mow the species of interest for a few seasons to observe the response.

Attribute 13: Herbicide Compatibilities

The Species Advisory Panel would like to see information on herbicide compatibilities, although there is very little available. Most of the research on herbicides and native plants focuses on killing native plants, not growing them. Native plants have only recently become crop plants. The Plant Materials Centers and some Agricultural Extension Services have begun publishing field studies in which herbicide use is recorded. Some research has been conducted in using herbicides, especially Plateau, to establish native meadows. Herbicide labels list the crops they can be used with. The Plateau label, for example, can be found at the BASF website, www.vmanswers.com/lib/productslist.aspx?CategoryID=268&SiteID=-1 .

A specific concern is compatibility with the herbicide typically used to control Canada thistle (*Cirsium arvense*), a listed noxious weed in Maryland. SHA prefers to control Canada thistle with spot treatments of Transline (Maryland SHA 2003). Clopyralid is generally safe on grasses and particularly damaging to members of the tomato family (Solanaceae) and the daisy family (Asteraceae).

Attribute 14: Road Salt Tolerance

The Species Advisory Panel recommends obtaining information on the tolerance of species to the chemicals used for de-icing. Unfortunately, we have not been able to find any such information in the literature. However, there is some information on the tolerance of various species to sea salt spray. It seems likely that species tolerant to sea

salt spray will be easier to find on the Eastern Shore, whereas more road salt is probably applied west of the Bay.

One way to approach the question is to observe which species can be found close to road shoulders. Unfortunately, these areas are also low-mow zones, and species there can be hard to identify. This may simply be one of those factors that will have to be determined with experience.

4.1.4 Affordability and Agricultural Considerations

Although the SHA does not typically need to contemplate the agricultural qualities of a seed crop, the Species Advisory Panel needed to do so in order to evaluate and recommend species to be targeted for development of local ecotype seed availability. SHAs stake in this issue is that it wants to be able to buy local ecotype seed at reasonable prices. SHAs interests can only be promoted by selecting those species that have qualities that lend themselves to affordable seed production. The agricultural considerations put forth by the Advisory Panel are:

1. Ease of controlling weeds in production fields - Weed control is a significant cost in the production of any crop. Weeds compete with all crops for moisture, nutrients and light. Weeds can be even more of a problem in seed crops. If the weed produces seeds that resemble those of the crop in size and weight, it can be very difficult (and expensive) to remove them during the seed cleaning process.
2. Abundance of seed - Species that produce a large number of viable seeds per unit field area will sell for less money per seed. Many small-seeded plants produce thousands of seeds per square foot of farm field.
3. Ease of harvest - Native seed can be difficult to harvest. For example, in some species seed ripens over a long period of time such that some portion of the seed is shattering or blowing away while another portion of the seed on each plant is not ripe yet. Others hold their seed until all is ripened, and then begin to disperse it. The latter species are easiest to harvest. Species that can be produced in large fields and harvested mechanically can be produced affordably.
4. Ease of seed cleaning - Some species have seed that is nearly clean as harvested, or clean very easily after harvest. Other species can require considerable machine processing. The worst case scenario occurs when the machines break stems and leaves down into pieces that resemble the seeds in shape or weight, making them time-consuming to impossible to remove with sieves and blowers.
5. Shelf life - Some species will store at room temperature and humidity for more than three years, and will keep even longer in cold storage. Others have very short shelf lives, in some cases less than a few weeks. From the seed producer's point of view, shelf life is an insurance policy, allowing a seed crop that did not sell one year to have additional years of marketability. Seed that has a very short shelf life will be more expensive and/or less available due to the risk that the grower may not sell the crop at all.

4.2 Application of the Attributes List to Example Species

In this section we illustrate the proper use of the Attributes List (Table 4) through the analysis of three species.[9] Although commonly recommended for roadside meadows and Conservation Reserve Plantings in Maryland, we will find that these species do not have the qualities we are seeking for roadside use. Each of these species was carefully selected because their review illustrates how to avoid a misstep in the Attributes review process. All the same, review of these three species is short because they are quickly eliminated.

In each of the 2nd, 3rd and 4th reports of this series, we will review a species that ultimately advanced to field trials. In those reports, the review not only serves as an example of how to use the Attributes List, but also as an introduction to the species discussed in the remainder of that report.

4.2.1 A Straight Forward Example of Attribute 1

In some instances, review of the Native Status Attribute is quite straightforward. Blanket flower (*Gaillardia pulchella* Foug.) has compelling qualities for roadside use, with its short stature and brilliant color. However, references indicate it is not native to any part of Maryland.

1. A. Native Status
    a. **Shetler and Orli (2000)** do not list the species as a member of the Baltimore-Washington flora.
    b. **Brown and Brown (1984):** The species is not even indexed in Herbaceous Plants of Maryland.
    c. The alien status is confirmed by several other sources (**USDA PLANTS database**, 2009; Flora of North America, 1993).

Consideration of the additional Attributes is not warranted, and the entire Attributes review process required only a few minutes.

4.2.2 A Complex Example of Attribute 1

In other instances, comparison of the species with even just Attribute 1 is complicated. Take for example common yarrow (*Achillea millefolium*).

1. A. Native Status
    a. **Shetler and Orli (2000)** indicate that the species is native,
    b. **Brown and Brown (1984)** describe the species as "a common and abundant weed, chiefly in pastures and permanent meadows; also roadsides and waste areas" and then go on to describe a cultivar that is known to escape.
    c. **Metzger (1995)** indicates that the species is an exotic that has naturalized in Maryland, but that some races may be native.

[9] The reader may wonder why the authors are discussing a method, specifically a method of evaluation, in the results section of this report. We are in the awkward position of all authors whose result is a method.

d. **The PLANTS Database** (USDA NRCS 2009) indicates that 12 varieties of *Achillea millefolium* are currently recognized within North America. One is native in Maryland, whereas the others are not. One is not native anywhere in North America, and is on some invasive species lists. This raises several questions. If there is a variety of yarrow native to Maryland, how would we recognize it, and is it rare or common? Are vendors offering the native or the invasive variety? For this species, consideration of Attribute 1 alone will be very time consuming. It would be best to delay the use of this species until an expert can review the complexities.

4.2.3 Examples of References that Provide Conflicting and Faulty Information

Big bluestem (*Andropogon gerardii* Vitman) easily passes Attribute 1, with all references indicating that it is native to Maryland (Brown & Brown, 1984; Metzger, 1985; Shetler & Orli, 2002; USDA Plants 2009). Proceeding to Attribute 2, we ask how abundant or representative the species is of Maryland meadows, and what its natural distribution is like.

2. Abundance and Natural Distribution

   a. **State Rarity:** The book Rare, Threatened, and Endangered Plants of Maryland (Maryland Department of Natural Resources 2007) indicates there are no rare *Andropogon* in Maryland. There are no synonyms for big bluestem that start with a different genus name.

   b. **Brown and Brown (1984)** describe the occurrence of big bluestem in Maryland as "Dry or wet soils and in open woodland; infrequent throughout". At this point in our review, we can conclude that the plant is probably infrequent but not so rare as to be tracked by the Maryland Heritage Program.

   c. The Maryland Native Plant Society Website

   i. Contains plant lists for many of their field trip sites throughout the State (www.mdflora.org/plantinfo/plantlists/lists_by_county.html). The lists do not separate plants that are native to the field trip site from those that might have been introduced. None of the field trip lists mention big bluestem, another indication that it is not common. If the species were listed, we might contact the list's author for more information.

   ii. Also contains plant lists developed by others (www.mdflora.org/survey_data/survey_data.html). The book Native Plants for Anne Arundel County is a compilation of other plant lists prepared by the Master Gardeners of Anne Arundel County (Gallagher *et al.* no year given). They have listed big bluestem as native. I contacted the lead author to determine the information used to determine native status. The list was based on information provided in Brown and Brown (1984) and the statement "infrequent throughout" was interpreted as "present throughout, but infrequent", which would mean that the plant was native to Anne Arundel County. The list is a good example of citizens stepping in to fill a void where scientists have failed to provide needed information.

d. **Park/Government Property Lists:** *Plants of Jug Bay Wetland Sanctuary* is a list of several plants that can be seen in that park. Big bluestem is on the plant list, and at first review of the list one might easily think that this means big bluestem is native to the park. Therefore I contacted the list author, who stated that the big bluestem is thought to be a remnant of old Conservation Reserve Plantings in the farm fields there (Karyn Molines, list author, pers. comm. 2009).

e. **Marylandica:** contains a plant list for natural communities in the Anacostia watershed (Simmons *et al.* 2008). The authors list *Andropogon glomeratus*, *A. ternarius*, and *A. virginicus,* but not *A. gerardii*.

f. **University of Maryland Norton Brown Herbarium:** If we were truly proposing the species for consideration, we would visit the herbarium, which only requires an hour or so of effort.

g. **Author's Observations:** In our fieldwork in Maryland, we have only seen big bluestem in the permanent meadows of serpentine barrens. We have never seen it within the Coastal Plain geographic province.

These data support Brown and Brown's assertion that big bluestem is infrequent, and would lead a reviewer to suspect that *Andropogon gerardii* is not a species that represents Maryland very well. Unless it had some compelling quality not possessed by a more representative native grass species, it should not be considered for use on Maryland roadsides. One potential example of a compelling quality would be if big bluestem were the only native grass capable revegetating some particular type of highly disturbed soil environment. In such a scenario, using the knowledge gained through the Attributes review process, we would be in a better position to consider the genetic impact that large-scale roadside use of big bluestem might have on the tiny and highly specialized populations adapted to life in Maryland's serpentine ecosystems.

4.3 Species Selected

After a cursory review of the list of common Maryland native meadow plants relative to the Attributes (Table 4), it was the opinion of our Advisory Panel that the species listed in Table 5 are ten of the most appropriate for use on Maryland roadsides. Although resources limit us from moving forward with the development of local ecotypes of all ten species immediately, we did choose from this list for our inaugural species. Future species to be developed could also be chosen from this list. The first step in such a development should be a thorough review of the Attributes of each species. The development of this list is the second accomplishment of this project and is a stand-alone result. It can be used now to purchase what seed is available from Maryland sources or to guide future development of additional seed sources. In addition, this list was used to guide the next phase of our project, the wild-collection phase.

Table 5: Top Ten Species for Use on Maryland Roadsides

Common Name	Scientific Name
Maryland goldenaster	*Chrysopsis mariana* (L.) Elliot
Virginia wildrye	*Elymus virginicus* L.
Purple lovegrass	*Eragrostis spectabilis* (Pursh) Steud.
Shrubby lespedeza	*Lespedeza frutescens* (L.) Hornem.
Nuttall's lespedeza	*Lespedeza nuttallii* Darl.
Beaked panicgrass	*Panicum anceps* Michx.
Florida paspalum	*Paspalum floridanum* Michx.
Talus slope beardtongue	*Penstemon digitalis* Nutt. ex Sims.
Gray goldenrod	*Solidago nemoralis* Aiton
Canada germander	*Teucrium canadense* L.

4.4 Wild Collection

We began the Wild Collection Phase looking for sources of all ten species on the list approved by our Species Advisory Panel (Table 5), assuming (correctly as it turned out) that our success or failure in the hunt would become the limiting factor. Some of the species were eliminated from the program because we were unable to locate the minimum number of parent populations. Maryland goldenaster was eliminated because we were unable to collect from any of the Piedmont locations – they were mowed before the seed ripened. Although we made many successful collections of purple lovegrass, we had better luck with the other warm season grass on our list, beaked panicgrass. The latter also appeared to be more of a generalist in habitat requirements, and so we eliminated the purple lovegrass from consideration. Nuttall's lespedeza was difficult to locate in the wild. We were unable to locate any populations of Florida paspalum in the Piedmont, and in this inaugural project we wanted to select species with a statewide distribution. It was surprisingly difficult to find wild populations of foxglove beardtongue, a rather aggressive and once very common wildflower. We were only able to locate one population east of the Bay, two in the Coastal Plain west of the Bay, and two in the Piedmont. The results for Germander were even more surprising. Anyone who has grown it in the garden knows it is a thug, and once it was very common in Maryland. We only found one population in the state.

In a few cases we were unable to comply with all the collection recommendations mentioned in our methods section. For example, the Bureau of Land Management (2008) recommends collecting seed on multiple dates, but we were only able to collect seed for some species from some parent populations on one date. This raises the possibility of a genetically skewed collection if variation in ripening date were related to genetic variation among individuals. We did not notice variation of ripening date among individuals within the same population. However, we did notice variation on the same plant, especially the goldenrods, with seed in one part of a panicle ripe while the remainder was still ripening. Since all that variation is within the individual, coming back a second time would not improve the genetic diversity of the seed collection. We

also noticed variation in ripening date among populations. In the case of one population of beaked panicgrass, we think that was because it had been mowed. Variation among populations was adequately sampled by our technique because each population was sampled when the seed was ripe.

We found enough gray goldenrod, beaked panicgrass and Virginia wildrye populations to satisfy the needs of the project, and so these were the three species that were advanced to the production trials. Greater detail on wild collection results of these three species is provided in the individual reports that follow.

5 Conclusions and Recommendations for Implementation

1. A Species Advisory Panel was developed to provide expertise from local agricultural, environmental and roadside vegetation management organizations (Table 2). The Panel members provided hours of useful consultation at no cost. The Panel can be re-convened by SHA whenever needed to provide further recommendations on appropriate species for roadside use.
2. The Attributes review process presented in this report (Table 4) is a reproducible, non-arbitrary method for evaluating species prior to approving them for use in roadside stabilization projects.
3. From the initial list of 30 locally native species considered for this project, the Species Advisory Panel selected a short list of ten (Table 5) that should be further investigated for both roadside slope stabilization and large-scale, affordable, agricultural production potential. This project has brought three of the ten species to the production phase.
4. The three species of seed that were wild-collected across the state are Virginia wildrye, beaked panicgrass, and gray goldenrod. Wild seed was used to study germination behaviors and to produce plugs for breeder block and production plots at private farms and at the National Plant Materials Center in Beltsville. The Attributes of these three species and the results of our work are discussed in the next three reports of this series.
5. Recently a number of authors have indicated that local ecotype seed is both the most successful in roadside revegetation projects, and the best choice for preserving the genetic integrity of local populations. Since it can only be produced locally, it is always the best choice for supporting Maryland's economy. This makes local ecotype seed the choice most consistent with SHAs mission statement. We recommend that SHA begin preferentially purchasing locally native seed whenever certified source-identified stock is available.

6 Future Work

1. **Build Our Coalition:** We should cultivate and expand the alliances built during this project.
   a. The Maryland Department of Agriculture would make a valuable addition to the Species Advisory Panel.
   b. Iowa has demonstrated the value of a vigorous department of transportation-university-nonprofit-USDA team like ours. Like our Advisory Panel, they formed to "promote commercial availability and affordability of Source Identified seed". Since 1939, the USDAs 27 Plant Material Centers have made 466 releases; 29 of these were made in cooperation with the Iowa team since their inception in 1990 (Belt & Englert 2009). The Iowa team estimates that, since their founding in 1999, they have helped restore 10,000 roadside acres to native vegetation. They have released 81 ecotypes of 33 species for commercial production. Their farmers produce over 60,000 pounds of source-identified seed annually (www.tallgrassprairiecenter.org /).
2. **Review the Attributes of More Species:**
   a. Begin review of the remaining 7 species on the short list of 10. Having the review results available will direct the future development of soil stabilization seed releases, and it will help SHA design consultants select species for wildflower meadows and formal landscapes.
   b. Use the Attributes review process to reevaluate the existing species lists in the SHA Standard Specifications for Construction and Materials (2008). There are many good recommendations on those lists, and the review process will point out any species SHA should reconsider.
3. **Attributes vs. Criteria:** The Attributes review process empowers SHA to work from a position of knowledge. It is not a set of criteria. The option of developing a set of criteria, or possibly assigning a point system to the species evaluation process should be investigated.
4. **Secure Success by Adding Species:** Stabilization projects occur on all types of soil, slope, slope aspects, light, and climate. To ensure success under these diverse conditions, it is necessary to add species to the initial cadre of three. It is also necessary if we are to ensure that our activities enhance Maryland's environment (Table 2: 7). Much as we have come to learn the environmental cost of planting the same few alien species on all disturbed soils, we are likely to learn that there is also an environmental cost to planting only three native species on all disturbed soils. We have a list of species to target (Table 5). Given the level of expertise and the diversity of perspectives present on the SAP, the short list has tremendous value for SHA. We recommend that the Attributes of the remaining seven species undergo vigorous review. If appropriate, local ecotype breeder blocks of these species should also be developed for agricultural production and roadside use.

7 Glossary

Several references were used in developing this glossary, but especially Davis *et al.* (2002), Smith and Halbrook (2004), and Ogle and Englert (2008). The glossary is botanically focused and ignores meanings or differences in meaning that terms may have when applied to other types of life.

Accession – Something added to a collection. In this paper it refers to a sample of seed collected from a wild parent population. It may also refer to the plants grown from that seed, since the two are genetically identical. In contrast, parent population refers to the group of plants at the wild location where the seed was collected.

Adjuvant – Another chemical that is mixed in with the primary herbicide that makes it even more effective than it would be alone, often a chemical that breaks down water tension and allows spray to spread evenly over the surface of a plant.

Alien species – A plant that was not present in a determined place prior to the arrival of humans. The determined place can be narrowly defined as the place under your feet with its peculiar ecotypical conditions (niche), or as widely as the entire continent.

Alloploid – A hybrid individual having two or more sets of chromosomes derived from two different species. (The same as Allopolyploid.)

Apical dominance – Hormonal domination of lower buds by the bud at the apex or tip of the plant. When this bud is cut off, lower buds along the stem and rhizomes are released and begin to grow.

AOSCA– Association of Seed Certifying Agencies.

Apomixis – Reproduction in which the ovary takes part, but there is no fertilization by the pollen grain. The plant produces a seed that is genetically identical to the mother plant.

Autogamy – Reproduction without contribution of male genes (pollen). Offspring are genetically identical to the mother plant.

Breeder block – A collection of plants grown directly from wild seed (or other propagules). It has a genetic composition representative of the wild population from which it was taken and is considered Generation 0. Breeder blocks are typically used by the people who will be releasing foundation seed to farmers.

Caryopsis – a type of fruit characterized by a dry outer layer attached to the single seed inside. This type of fruit is characteristic of many grasses and often referred to as a grain.

Clopyralid –A selective herbicide (3,6-dichloro-2-pyridinecarboxylic acid) used for control of broadleaf weeds, especially thistles and clovers.

CNI – Abbreviation for Chesapeake Natives, Inc. CNI is a 501(c)3 nonprofit organization that was founded in 2005. Both authors are affiliated with CNI.

Cotyledon –The seed-leaves of a plant embryo. These are very easily seen in bean seeds, they wither away as the first true leaves emerge. The number of cotyledons is used to divide the flowering plants into monocots (grasses, lilies, etc.) and dicots (beans, maples, etc.).

Culm – The aerial stem of a grass or sedge.

Cultivar – An assemblage of cultivated plants clearly distinguished by heritable (genetic) traits (morphological, physiological, cytological, chemical, other). USDA cultivars have been through replicated testing at multiple sites over two or more generations to prove and document the heritability of these traits, the superiority and/or performance, and the range of adaptation.

Diploid – An organism with two copies of each chromosome, one from each parent. If you visualize the chromosomes in the nucleus as a collection of letters in the alphabet, mostly looking like distorted x's, y's and k's, a diploid organism has a full set of the letters normal for its species.

Founder's effect – A reduction in genetic diversity that occurs when a fragment of a population founds (or is used by people to found) a new population. Generations of inbreeding within the small gene pool leads to an increase in the expression of recessive traits, including some mutations and susceptibility to diseases. The current Wikipedia page (en.wikipedia.org/wiki/Founder_effect) has several interesting examples of Founder's effect in human populations.

Generation one – The generations of offspring since the initial material was collected are counted, with generation zero representing the wild parent material or seed that was wild collected. Plants face selection pressures in cultivation, and these are not the same selection pressures they face in the wild. With each generation in cultivation, the population becomes less and less like its wild ancestors.

Genetic erosion – The accelerated loss in genetic diversity of crop species or of native plant species caused by human activities.

Genetic diversity –The total amount of genetic variation present in a population or species. Diversity allows individuals to react differently to external conditions. The classic example of the danger of a lack of genetic diversity to plant (and human) survival is the potato blight of the 1840s. All the potatoes responded the same way to the infection.

Germination – The initiation of the growth of a plant from a seed.

Glumes – The bracts that enclose the spikelet of a grass (often also applied to sedges). The glumes may enclose one or more flowers. Details of glume morphology are important in species identification. Glumes, lemma and palea are part of the chaf that are threshed out from grains of wheat and rice prior to consumption.

Glyphosate – a broad spectrum herbicide, trade name Roundup, also sold under other trade names since Monsanto's patent expired in 2000.

Habitat fragmentation – The parsing of once large tracts of habitat into ever smaller tracts. Fragmentation leads to the genetic isolation of plants into unnaturally small populations. Isolation puts these small populations at increased risk for obliteration by

random events, including generational genetic developments that are random rather than adaptive (population bottlenecking).

Haplome (Haploid) – A single set of chromosomes in the Triticae half of a diploid set that has come from an intergeneric hybridization event. If you visualize the chromosomes in the nucleus as a collection of letters in the alphabet, mostly looking like distorted x's and k's, a haplome is a set consisting of half of each of those letters, half of the x, half of the k, etc.

Hostplant – A plant that hosts insects and other organisms, usually but not always larval insects (like caterpillars) that cannot feed on other types of plant tissue. The most famous example of a hostplant and its larval insect is probably the milkweed and the monarch butterfly caterpillar.

Imazapic - A selective herbicide **Plateau use for the release of native warm season grasses**

Lemma – The outer, leaf-like bract of a grass-flower, and enclosing a single grass seed.

MDA – Maryland Department of Agriculture.

Multipot – Trademark product of the Ropak Corporation, a re-usable, deep plug tray made to grow seedlings for transplant into the field.

Native species – A type of plant that was present in a determined place prior to the arrival of humans. The determined place can be narrowly defined as the place under your feet with its peculiar ecotypical conditions (niche), or as widely as the entire continent.

Niche – The place an organism occupies in its habitat. The place is not merely a physical location, but also the place in the food web, and the place along environmental gradients (moisture, salinity, light, soils, etc.).

NPMC – The National Plant Materials Center, the lead Plant Materials Center of the USDA, NRCS located in the Beltsville Agricultural Research Center, Beltsville, Maryland.

NRCS – Abbreviation for the Natural Resources Conservation Service, one of 27 Agencies within the USDA. Prior to 1997 NRCS was known as the Soil Conservation Service.

Oryzalin- A preemerge herbicide for control of grass common trade name Surflan

Panicle – A compound flower head (inflorescence) containing a main stem and many branching branches, often plume-like or loosely pyramidal in outline. The flowers on one panicle do not all bloom at the same time (indeterminate). Both beaked panicgrass and gray goldenrod hold their flowers in panicles.

Polyploidy – The condition of having more than two fully paired sets of chromosomes (see for example alloploidy).

Population – A group of plants that can breed with each other, exchanging genetic information through the transfer of pollen or spores.

Parent population – In any field of science, a group of individuals from which a smaller sample is drawn. In our work, the group of individuals is a collection of wild plants at one location, and the sample is a seed collection.

Radicle – The first root to emerge from a seed, the embryonic root.

SHA – Maryland State Highway Administration.

Source-identified -Seeds or plants from a naturally growing population occupying a known or defined geographic area. No selection or testing of the parent population has been made. There is no performance or adaptation data available for the collection. Offspring is produced to ensure genetic purity and identity from rigidly defined natural stands, seed production areas, seed fields, or orchards.

spp. – Standard abbreviation for two or more species of a genus.

ssp. – Standard abbreviation for subspecies.

Stratification – A pre-treatment of seed, often to cold, moist conditions, that enhances germination rates, mimicking natural conditions.

Tetraploid – An organism with four copies of each chromosome. If you visualize the chromosomes in the nucleus as a collection of letters in the alphabet, mostly looking like distorted x's and k's, a tetraploid organism has two full sets of the letters normal for its species. However, in some species, all the members are tetraploid.

Tribe – **S**cientific classification of species usually include the following levels: Kingdom, Phylum, Order, Family, Subfamily, Genus, Species. Some authors, including Brown and Brown (1984), use Tribe as a level in classifying the Grass Family. The tribe Triticeae includes wheat, rye, barley, wheatgrass and wildrye.

Trifluralin a preemerge herbicide for control of grasses common trade name Treflan

var. – The botanical convention abbreviation of "variety", a taxonomic category subordinate to species. Variety can also have other meanings, even with respect to plants, depending upon the context.

USDA – United States Department of Agriculture.

8 References

Annotated Code of Maryland**.** The Erosion And Sediment Control Regulations (COMAR 26.17.01). http://www.dsd.state.md.us/comar/. Accessed 11/27/09.

Ayres, D.R., D. Garcia-Rossi, H.G. Davis & D.R. Strong (1999). Extent and degree of hybridization between immigrant (*Spartina alterniflora*) and native (*S. foliosa*) cordgrass (*Poaceae*) in California, U.S.A. determined by random amplified polymorphic DNA (RAPDs). *Molecular Ecology* **8**: 1179-1186.

Barkworth, M.E., J.J.N. Campbell & B. Salomon (2006). *Elymus* L. *In*: Flora North America Editorial Committee (Eds.). *Flora of North America North of Mexico* Vol. **24**: 288-343. Magnoliophyta: Commelinidae (in part) Poaceae, part 1. Oxford University Press, New York. Manuscript. version also available at www.herbarium.usu.edu/webmanual (accessed on 5/01/09).

Baskin, C.C. and J.M. Baskin (1998). Seed Ecology, Biogeography, and Evolution of Dormancy and Germination. Academic Press, San Diego, CA. 666pp.

Beck, K.G, K. Zimmerman, J.D. Schardt, J. Stone, R.R. Lukens, S. Reichard, J. Randall, A.A. Cangelosi, D. Cooper & J.P. Thompson (2008). Invasive Species Defined in a Policy Context: Recommendations from the Federal Invasive Species Advisory Committee. *Invasive Plant Science and Management*. **1**: 414–421.

Belt, S.V. & J.M. Englert (2008). Improved Conservation Plant Materials Released by NRCS and Cooperators Through December 2007. USDA Natural Resources Conservation Service, National Plant Materials Center.

Booze-Daniels, J., D.R. Chalmers & R.E. Schmidt (1998). Native Grasses on the Roadsides of Virginia - A Review of Literature. A Report to Virginia Department of Transportation submitted by Department of Crop, Soil and Environmental Science, Virginia Polytechnic Institute and State University.

Brown, M.L. & R.G. Brown (1984). *Herbaceous Plants of Maryland*. Port City Press, Inc., Baltimore, Maryland. 1127pp.

Brown, M.L. & R.G. Brown (1984). *Woody Plants of Maryland*. Port City Press, Inc., Baltimore, Maryland. **pp.

Bureau of Land Management (2008). Technical Protocol for the Collection, Study, and Conservation of Seeds from Native Plant Species for Seeds of Success. www.cbgseedbank.org/forms/CBG%20Collection%20Protocol.pdf (accessed 2008).

Carver, E. (2009). Birding in the United States: A Demographic and Economic Analysis. United States Fish and Wildlife Service, Report 2006-4. Arlington, VA.

Chesapeake Natives, Inc. (2009). The Species Webpages. www.chesapeakenatives.org/Chesapeake_Natives_Draft/Species.html Accessed June 2009.

Dale, C.G. (1993). LCMR Final Status Report: Native Grass and Wildflower Seed. Minnesota Dept. of Agriculture.

Davis, K.M., J.M. Englert & J.L. Kujawski (2002). Improved Conservation Plant Materials Released by NRCS and Cooperators Through September 2002. USDA NRCS National Plant Materials Center. www.plant-materials.nrcs.usda.gov/mdpmc/publications.html

Deno, N.C. (1993). *Seed Germination Theory and Practice*. 2nd Edition. Published by the author: 139 Lenore Dr., State College Pennsylvania 16801

Federal Highway Administration (2002). Greener Roadsides: An FHWA Quarterly Newsletter for Roadside Decision Makers. Summary of the 2002 Seeds of the Future Conference in Orlando, Florida. www.fhwa.dot.gov/environment/greenerroadsides/winter02.htm#toc

Freckmann, R.W. & M.G. Lelong (2003). *Panicum.* pp. ***-***. *In*: Flora of North America Editorial Committee (Eds). *Flora of North America North of Mexico* Vol. 25 Magnoliophyta: Commelinidae (in part) Poaceae, part 2. Oxford University Press, New York. www.herbarium.usu.edu/webmanual (accessed 7/01/09).

Gelbard, J.L. & J. Belnap (2003). Roads as conduits for exotic plant invasions in a semiarid landscape. *Conservation Biology* 17(2): 420-432

Grabowski, Janet, B. Baldwin and P. Meints. 2004. Selecting for Improved Seedling Establishment in Beaked Panicum. *Jamie L. Whitten Plant Materials Center 2004 Annual Technical Report.* p.16-17.

Greenberg, C., S.H. Crown & D.R. Gordon (1997). Roadside soils: A corridor for invasion of xeric scrub by nonindigenous plants. *Natural Areas Journal* **19**: 99-109.

Gould, L. (2000). *Lady Bird Johnson: Our Environmental First Lady*. University of Kansas Press, Lawrence, Kansas.

Gustafson, D.J., D.J. Gibson & D.L. Nickrent (2004). Conservation genetics of two codominant grass species in an endangered grassland ecosystem. *Journal of Applied Ecology* **41**: 389-397.

Gustafson, D.J., D.J. Gibson and D.L. Nickrent (2005). Using Local Seeds in Prairie Restoration: Data Support the Paradigm. *Native Plants Journal* **6**(1): 25-28.

Henderson, K. (2002). The Iowa Ecotype Project, a presentation to the Seeds of the Future Conference, Orlando, Florida. www.fhwa.dot.gov/environment/greenerroadsides/win02p5.htm

Highway Beautification Act (1965). www.oah.org/pubs/magazine/firstladies/koman-doc1.html (accessed 12/31/05).

(accessed 8/28/09).

Jenkins, A.M., D.R. Gordon, M.T. Renda (2004). Native alternatives for non-native turfgrasses in central Florida: germination and responses to cultural treatments. *Restoration Ecology* **12**(2): 190-199.

Johnson, Lady Bird, & C.B. Lees (1993). *Wildflowers Across America*. Abbeville Press. New York. 312 pp.

Kartesz, J. & C.A. Meacham (1999). *Synthesis of the North America Flora*. Version 1.0 (CD-ROM). North Carolina. www.bonap.org/synth.html

Koman, Rita G. (2001). ". . . to leave this splendor for our grandchildren": Lady Bird Johnson, Environmentalist Extraordinaire, Org. of Am. Historians Mag. of History, v15.

Landis, T.D., K.M. Wilkinson, D.E. Steinfeld, S.A. Riley & G.N. Fekaris (2005). Roadside revegetation of forest highways: new applications for native plants. *Native Plants Journal* **6**(3): 297-305.

Latham, R. (2006). Native Grasslands and Meadows in Pennsylvania. *In*: M. Sanderson (Ed.). Proceedings of the 5th Eastern Native Grass Symposium. Omni Press, Wisconsin.

Linhart, Yan B. (1995). Restoration, revegetation, and the importance of genetic and evolutionary perspectives. In *Proceedings: Wildland Shrub and Arid Land Restoration Symposium 1993*. US Forest Service General Technical Report INT-GTR-315. Roundy, B., D. MacArthur, E. Durrant, J. Haley and D. Mann, eds.

Mack, R.N. (1991). The commercial seed trade: An early disperser of weeds. *Economic Botany* **45**: 257-273.

Maryland Department of Environment (2004). Maryland Standards and Specifications for Soil Erosion and Sediment Control.

Maryland Department of Natural Resources (2007). Rare, Threatened and Endangered Plants of Maryland. www.dnr.state.md.us/wildlife/espaa.asp

Maryland Department of Transportation (2007). Fiscal Year 2008 Through Fiscal Year 2011 Business Plan. www.marylandroads.com/oc/shabusinessetnl.pdf , accessed 6/1/09

Maryland Native Plant Society (2002). Guidelines for Collecting Seeds From Native Plants. www.mdflora.org/publications/gguidelines02.pdf

Maryland State Highway Administration (2003). Integrated Vegetation Management Manual for Maryland Highways.Maryland Dept. of Transportation. 144 pp.

Maryland State Highway Administration (2008). State Highway Administration's Standard Specifications for Construction and Materials. 792 pp.

McKay, J., C. Christian, S. Harrison & K. Rice (2005). How Local is Local? *Restoration Ecology* **13**(3): 432–440.

Metzger, J. 1995. Maryland Native Plants: A Master Checklist. www.mdflora.org/publications/mdchecklist.pdf

Miller, R.M. (1997). Prairie Underground *in* The Tallgrass Restoration Handbook. Stephen Packard and Cornelia F. Mutel (eds.) The Society for Ecological Restoration. Island Press. Washington, D.C.

Moore, A. (2009). Map of the Major Land Resource Areas of Maryland. Prepared for this report by the State Soil Scientist, USDA Natural Resources Conservation Service.

Munda, B. and S. Smith (1995). Genetic variation and revegetation strategies for desert rangeland ecosystems. US Forest Service General Technical Report INT-GTR-315. Roundy, B., D. MacArthur, E. Durrant, J. Haley and D. Mann, eds.

National Academy of Sciences (2003). *Predicting Invasions of Nonindigenous Plants and Plant Pests*. Richard N. Mack, Chair. National Academy Press, Washington, D.C.

Norcini, J.G., J.H. Aldrich, L.A. Halsey & J.G. Lilly (1998). Seed Source Affects Performance of Six Wildflower Species. *Proceedings of the Florida State Horticultural Society* **111**: 4-9.

Noss, R. (1999). Restoring Grassland Ecosystems: An Opportunity to Save the Pieces in Roadside Use of Native Plants, Bonnie Harper-Lore, (ed.) Federal Highway Administration. www.fhwa.dot.gov/environment/rdsduse/ (accessed 12/21/05).

Ogle, D. & J. Englert (2008). *Glossary of Terms for Use in Plant Materials*. USDA Natural Resources Conservation Service. Boise, Idaho. 48 pp.

Parendes, L.A. & J.A. Jones (2000). Role of light availability and dispersal in exotic plant invasion along roads and streams in the H.J. Andrews Experimental Forest, Oregon. *Conservation Biology* **14**: 64-75

Pfaff, S. (2002). *Florida Native Seed Production Manual*. USDA NRCS, Brooksville, Florida. 76 pp.

Reichard, S.H. & P. White (2001). Horticultural introductions of invasive plant species: a North American perspective. *In*: McNeely, J.A. (ed.). *The Great Reshuffling: Human Dimensions Of Invasive Alien Species.* International Union for Conservation of Nature and Natural Resources, Gland, Switzerland.

Richardson, S. (1997). Development of Native Seed Sources and Establishment Methods for Native Upland Reclamation. USDA NRCS Plant Materials Center, Brooksville, Florida. 23 pp.

Richardson, S. (1999). Development of Native Seed Sources and Establishment Methods for Native Upland Reclamation. USDA NRCS Plant Materials Center, Brooksville, Florida. 23 pp.

Rogers, D. (2004). Genetic Erosion. *Native Plants Journal* **5**(2): 113-122.

Schmidtling, R.C. (2001). Southern Pine Seed Sources. US Forest Service. General Technical Report SRS-44.

Shetler, S. & S.S. Orli (2000, 2002). *Annotated Checklist of the Vascular Plants of the Washington-Baltimore Area.* Part I and Part II. Dept. of Botany, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Simmons, R.H., J.M. Parrish, M.D. Tice, and M.T. Strong (2008). Conservation Priorities and Selected Natural Communities of the Upper Anacostia Watershed. *Marylandica* **12**(1): 1-23.

Slattery, B.E., K. Reshetiloff & S.M. Zwicker (2003). *Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed*. U.S. Fish & Wildlife Service, Chesapeake Bay Field Office, Annapolis, Maryland. 82 pp.

Smith, C. (2008). *Invasive Exotic Plants of North Carolina*. North Carolina Dept. of Transportation. www.se-eppc.org/northcarolina/NCDOT_Invasive_Exotic_Plants.pdf (accessed 8/27/09).

Smith, S.E. and K. Halbrook (2004). A plant genetics primer. *Native Plants Journal* **2004** (Fall): 106-111.

Tallamy, D.W. (2007). *Bringing Nature Home: How Native Plants Sustain Wildlife in Our Gardens*. Timber Press, Portland, Oregon. 288 pp.

Tangren, S. (2002). A photographic comparison of the performance of Lake Erie ecotype natives vs. Chesapeake ecotype natives during the drought of 2002. Unpublished observations available on request.

Terrell, E.E., J.L. Reveal, R.W. Spjut, R.F. Whitcomb, J.H., Kirkbride Jr., M.T. Cimino, & M.T. Strong (2000). Annotated list of the flora of the Beltsville Agricultural Research Center, Beltsville, Maryland. USDA, Agricultural Research Service. ARS-155.

U.S. Census Bureau (2000). quickfacts.census.gov/qfd/states/24000.html

USDA NRCS (2006+). The PLANTS database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Baton Rouge (LA). www.plants.usda.gov (accessed 2006 through 2009).

United States Department of Transportation, Bureau of Transportation Statistics (2000). Maryland Transportation Profile. www.bts.gov/publications/state_transportation_statistics/maryland/pdf/entire.pdf

Virginia Department of Conservation and Recreation and the Virginia Native Plant Society (2003). *Invasive Alien Plant Species of Virginia*. www.dcr.virginia.gov/natural_heritage/documents/invlist.pdf

Vogel, K.P., A.A. Hopkins, K.J. Moore, K.D. Johnson & I.T. Carlson (2006). Genetic Variation among Canada Wildrye Accessions from Midwest USA Remnant Prairies for Biomass Yield and other Traits. *Crop Science* **46**: 2348–2353.

Watkins, R.Z., J. Chen, J. Pickens & K.D. Brosofske (2003). Effects of forest roads on understory plants in a managed hardwood landscape. *Conservation Biology* **17**: 411-419.

Wildflower Seed & Plant Growers Association, Inc. www.floridawildflowers.com (accessed 12/20/05).

Young, Stanford A. (1995). Verification of germplasm origin and genetic status by seed certification agencies. In *Proceedings: Wildland Shrub and Arid Land Restoration*

Symposium 1993. US Forest Service General Technical Report INT-GTR-315. Roundy, B., D. MacArthur, E. Durrant, J. Haley and D. Mann, eds.

Young, S.A., B. Schrumpf, and E. Amberson. (2003). The AOSCA Native Plant Connection: The Need for Native Plant Genetic Information. Bulletin of the Association of Official Seed Certifying Agencies. Meridian, Idaho.

Zheng, H., Wu, J.,Ding, J., Binion, D., Fu, W. and .Reardon, R. (2004). *Invasive Plants of Asian Origin Established in the United States and Their Natural Enemies*. Vol. I. USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV, 26505. www.invasive.org/weeds/asian/

Zheng, H., Wu, J., Ding, J., Binion, D., Fu, W. and .Reardon, R. (2005). *Invasive Plants of Asian Origin Established in the United States and Their Natural Enemies*. Vol. 2. USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV, 26505.