Powerpoint Presentation:

VEGETATION ECOLOGY OF THE POTOMAC GORGE

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Originally presented:
Current version: at the October 14, 2006 annual meeting of the Maryland Native Plant Society in Shady Grove, Maryland. Previous versions were presented at the October 5, 2004 meeting of the Botanical Society of Washington, Smithsonian Institution Museum of Natural History, Washington, D.C; on March 6, 2004 at the Virginia Native Plant Society's 2004 Biodiversity Workshop, Lewis Ginter Botanical Garden, Richmond, Virginia; and at the April 8, 2004 meeting of the Potowmack Chapter of the Virginia Native Plant Society, Green Springs Garden Park, Annandale, Virginia.

Instructions:
The following script is designed to accompany the PDF version of this presentation, which is downloadable from the Division of Natural Heritage website. The first paragraph corresponds to the title (first) slide. Each subsequent "■" indicates a slide transition. The number following the "■" corresponds to the slide number displayed on the "Pages" tab of the PDF powerpoint.

Presentation:

■1 Welcome to the PDF version of the Virginia Division of Natural Heritage presentation "Vegetation Ecology of the Potomac Gorge." The purpose of the presentation is to provide an overview of the unusual physiography of the Potomac River Gorge, report on the classification of natural communities on the Virginia side of the river, and relate the distribution of these communities to environmental gradients.

■2 The Potomac Gorge encompasses a 24 kilometer (15 mile) stretch of the Potomac River valley from just above Great Falls to the vicinity of Georgetown in Washington, D.C. The valley in this stretch is deeply entrenched as the river drops 46 meters in elevation through rocks of the Fall Line at the eastern edge of the Piedmont Plateau. The south side of the river is in Virginia while the river itself and the north side are in Maryland and the District of Columbia. The Potomac Gorge has long been considered one of the most important natural areas in the mid-Atlantic region, and is especially significant because of its location within an urban and suburban setting. The boundaries of the Potomac Gorge enclose a 3900 ha (9700 ac) area defined by The Nature Conservancy as a high-priority conservation site containing more than 400 occurrences of rare species and communities in the three jurisdictions.

■3 In 2003, the Virginia Division of Natural Heritage began a three-year study whose primary purpose is to inventory and classify the late-successional, natural ecological communities on the Virginia side of the Gorge, and to integrate results with similar work completed on the Maryland and D.C. side. The project was funded in part through the National Park Service and considerable logistical support has been provided by The Nature Conservancy Maryland Field Office, the Fairfax County Park Authority, and Madeira School. The final report detailing this work will be completed in the spring of 2006.

The inventory and protection of natural communities has sometimes been referred to as a "coarse filter" approach to biological conservation, emphasizing the protection of ecological systems and all their components, both common and rare. The practical utility of this approach is that by protecting excellent examples of all natural communities in an area, the majority of that area's native biota can probably be protected. This is in juxtaposition to a "fine filter" approach that emphasizes the inventory and protection of individual rare species. The two approaches are not mutually exclusive and, in fact, complement each other very well. But what we want to do with this presentation is to use the Potomac Gorge project as a demonstration of how the "coarse filter" approach to inventory is applied at a landscape level.

■4 The study has several objectives. The first is to expand and refine existing information on ecological communities of the Gorge. Although two major studies have been conducted on the Maryland and D.C. side, no work relating directly to community classification has been done on the Virginia side. The second is to make future conservation planning for the Gorge easier. A third objective is to provide a sound ecological framework for management and stewardship of this area, as well as for vegetation mapping. A fourth objective is to reduce redundancy in management strategies for multiple rare species. In this era of limited resources, it is impractical to protect every rare species on an individual basis at a site like this. Moreover, due to quirks of political boundaries and plant distributions, some species are "rare" in Maryland but "common" in Virginia, and vice-versa. By identifying the affiliations of habitat, ecological process, and vegetation type that are shared among rare species, it is possible to direct appropriate management at the community level. Finally, we hope that this project will help identify and target needs for future inventory projects in the Gorge.

■5 We hope to build on three previous ecological studies. The first is a study of an old-age forest at Great Falls Park that used tree-ring chronologies to trace the successional history of the stand for the last 250 years. Chris Lea's masters thesis is an intensive study that established the relationships between vegetation composition, flooding frequency, and topographic factors on the Maryland and D.C. side of the Potomac Gorge. The Gold Mine Tract project by Chris Lea and Rod Simmons produced a classification of upland forests near Great Falls, Maryland. The last two studies employed methodologies similar to and compatible with those that we are currently using. Lastly, VANHP ecologists have been able to analyze all of the data from these studies and ours together as part of the ongoing vegetation mapping project for the National Capital Region parks, which makes it possible to produce an integrated, regional community classification for the entire Gorge.

■6 In this presentation, we will focus on the Virginia portion of this area but will discuss the relationship of landscape and vegetation patterns on both sides of the river. Over the years, Virginia Natural Heritage ecologists have had the opportunity to conduct inventories and research in all parts of Virginia. But hectare for hectare, the Virginia side of the Potomac Gorge is clearly one of the most complex and diverse landscapes we have worked in.

■7 This slide shows the location of the study area in the northern Piedmont physiographic province.

■8 The study area encompasses about 1200 hectares (3000 acres), most of which is in public ownership. Great Falls Park, Turkey Run Park, and the George Washington Memorial Parkway are units of the National Park system, while Riverbend Park and Scotts Run Nature Preserve are Fairfax County parks. We are also very fortunate to have permission to study vegetation on the large Madeira School property just downstream from Great Falls Park, and on a smaller area of private land along Bullneck Run east of Madeira.

■9 The Gorge is underlain by a complex suite of metamorphic rocks that can be divided into two major formations, the Mather Gorge and the Sykesville. The orange area in the middle is a transition zone of chaotic, highly sheared rocks that are difficult to classify.

■10 The Mather Gorge Formation consists largely of interbedded mica schist and metagrawacke, which is a slate-like metamorphosed sandstone. Some of the Mather Gorge rocks have been remelted in multiple episodes of metamorphism and are classified as migmatitic schists. Basic igneous rocks such as amphibolite and granodiorite also occur as local intrusions. The Sykesville Formation is a metasedimentary melange with a matrix of quartz and feldspar. Large, mappable intrusions of mafic and ultramafic rocks such as hornblend tonalite, soapstone, and metapyroxenite are intruded into the Sykesville, especially in the section of the Gorge through Turkey Run Park. As in the Mather Gorge Formation, some of the Sykesville rocks were remelted and exhibit white granitoid extrusions like the ones in the photo on the right. It should be noted that the abundant mica and feldspar in the matrix metasedimentary rocks increase the clay minerals, and hence the water-holding capacity, of many soils in the Gorge.

■11 The geomorphology and surficial geology of the Gorge is thought to be unique, or at least very unusual, among rivers draining the Atlantic slope. The present-day Gorge is the result of accelerated downcutting of the river into the resistant bedrock when sea level was lowered during the Pleistocene. As a result, the current channel morphology is controlled more by bedrock and less by alluvial processes than in most comparable stream systems. The progressive downcutting of the river left a series of prominent bedrock terraces above the current channel shelf. These terraces are especially extensive on the Maryland side of the river and probably represent former base levels of the river at different stages of erosion. The river has also migrated to the south over geological time and continually carved away at the Virginia shore, creating an almost continuous line of steep bluffs and cliffs. Thus the two sides of the river are now topographically now quite different: the Maryland side characterized by a more gentle terraced landscape, and the Virginia side marked by steeper, more dissected terrain.

■12 To give you a better feel for these features, the following sequence of slides represents a quick “tour” of the Gorge, starting at the upper end and proceeding downstream. For convenience, we can divide the Gorge into three sections based on general topographic features. In the upper section, the river flows more or less north – south and undergoes a rapid and dramatic transformation.

■13 At Riverbend Park, the Potomac is wide, relatively gentle, and flanked by substantial floodplains in most places. This is a view of the river in this gentle stretch above the Falls, in the northern part of Great Falls Park.

■14 Just above the falls, the river divides around Conn Island, crosses a low-water dam, and drops suddenly through a number of narrow channels that form Great Falls proper. This slide shows the westernmost channel of the Falls, just above the Great Falls Park, Virginia visitor center.

■15 This slide is a view of the Falls from the high bedrock terrace just downstream on the Virginia side. Overall the river drops 12 meters over a distance of 180 meters through the falls, an impressive sight even at low water.

■16 Below the falls, the river is funneled into Mather Gorge, a narrow, bedrock-lined passage less than 25 meters wide in places. Here, you are looking at the Virginia cliffs from the Maryland side, and you can clearly see the well developed, level bedrock terrace flanking the river on both sides.

■17 Although a pronounced terrace is present along the entire length of Mather Gorge in Maryland, on the Virginia side the terrace pinches out in the middle part.

■18 Thus, in the lower part of Mather Gorge, the Virginia side is lined by a very steep, wooded bluff with many cliffs and boulderfields.

■19 Difficult Run, one of the larger tributary streams on the Virginia side, enters the river at the end of Mather Gorge and itself has cut quite a rugged ravine through the bluffs.

■20 At the lower end of Mather Gorge, the river turns and then flows west to east through the Middle Section of the Gorge. In this section, the Maryland side is marked by very broad floodplains and terraces, while the Virginia side is lined with sheltered, north-facing bluffs and ravines. The part of this stretch through Scotts Run Nature Preserve and Turkey Run Park also has some of the larger intrusive bodies of base-rich mafic and ultramafic rocks, producing soils that are deep and fertile.

■21 At Madeira School, just below the mouth of Difficult Run, is one of the largest bedrock terraces on the Virginia side.

■22 This terrace contains a number of pools and ponds, the largest of which is Black Pond, a one hectare water body that apparently represents a Pleistocene channel of the river.

■23 Below Madeira, the river is wider but still swift as it negotiates its way around numerous islands.

■24 Some of these islands are very rugged and lined with substantial cliffs. This is Offutt Island and, beyond, the Virginia shore upstream of Bullneck Run.

■25 Downstream from Turkey and Vaso Islands, the river passes through rocky rapids called Stubblefield Falls, and Scotts Run drops into the river over an attractive waterfall. Below that, the river's flow becomes decidedly lower-gradient, with few rocks and rapids.

■26 This view shows the wooded, north-facing bluffs of the Virginia side below Stubblefield Falls, and is very representative of the entire stretch through Turkey Run Park and the remainder of the Middle Section.

■27 At the top of the Lower Section of the Gorge, the river once again turns to the south, passes over a low-water dam associated with a water intake facility, and then narrows through another bedrock passage at Little Falls.

■28 This is a view of Little Falls from the D.C. shore.

■29 At and below Little Falls, the D.C. side of the river has a large and unusual bedrock floodplain while the Virginia side is a precipitous cliff of the Sykesville melange.

■30 Below Little Falls, there are a few small bedrock areas on the Virginia shore as well, and several short, steep tributaries rush into the river. However, as you go downstream, this lower section becomes increasingly hemmed in by roads and urban development and several kilometers of former riverside cliffs were quarried away in the early 1800's, leading to a generally disturbed and altered condition today.

■31 Although the Potomac River may seem quite tranquil at some places and times in the Gorge, this pair of historical photographs illustrates just how deceiving the river may be. The first photo shows Mather Gorge at normal water level.

■32 Here is the same view during the flood that followed Hurricane Agnes in 1972. As you can see, this raging torrent completely covered the highest bedrock terraces flanking the Gorge. Floods of this magnitude occurred four times during the twentieth century. The normal flow of water over Great Falls is reported to be 349,000 liters a second, but during floods the flow commonly reaches 40 million liters a second, more than a hundred-fold increase.

■33 Floods such as the one shown here, which completely inundated the broad floodplain forests on the Maryland side in December, 2003, are relatively common, occurring every year or two.

■34 Unlike most eastern rivers its size, the Potomac's flooding regime is unchecked by high dams and it is powerful enough to completely destroy, rework, and create new floodplain habitats.

■35 A variation of this flood regime sometimes occurs during the winter, when water levels rise after the river has frozen over. Under these conditions, large ice sheets break up and move downstream at high velocity, severely scouring bars abd bedrock areas on and near the channel shelf.

■36 In the vicinity of Little Falls where ice floods are funneled through a narrow, bedrock passage, mechanical damage to soils and trees from periodic ice scouring maintains unusual large areas of openly wooded floodplain with large-scale hummock-and-pond microtopography.

■37 Although floods are very important in shaping plant habitats in the Gorge, periods of low flow, especially in late summer, expose substantial areas of alluvium that certain plants are capable of colonizing, albeit temporarily.

■38 To sum up this overview of the study area, the major factors contributing to the biotic richness of the Potomac Gorge include its complex geology, geomorphology, and topography; a

diversity of soil environments; diversity of wetlands and hydrologic regimes; a large river with a powerful, largely intact flooding regime; and a major water course that provides a ready corridor for the dispersal and migration of plants over several physiographic provinces.

■39 The methods used for this and similar ecological projects are based on standard Virginia Natural Heritage ecology group protocols and are based largely on the collection and analysis of quantitative data from plots placed in representative stands of vegetation. This plot-based methodology standardizes procedures for measuring, describing, and comparing vegetation from different sites, making it possible to circumscribe vegetation types in a much more rigorous way than would be possible using subjective observations from areas of indeterminate size. Although the analogy is not perfect, you could think of each plot as a "specimen" that can be compared with other plots in order to delimit vegetation "taxa," in much the same way as a botanist uses preserved plant specimens to determine the taxonomic limits of plant species.

■40 For inventory purposes, we employ 400 sq.m. plots in forest vegetation and 100 sq.m. plots in shrub or herbaceous vegetation. Although we typically use square quadrats, rectangular plot configurations were used as standards for this project. This is because the intricate side slopes, ridge spurs, ravines, and terraces of the Gorge are often short and/or narrow. Under these conditions, environmental gradients often change quickly, and it is easier to keep a rectangular plot confined to uniform environmental conditions and vegetation. At each plot we collect comprehensive data on the cover of all vascular plant species present; the maximum canopy height; measurements of all woody stems $\geq$ 2.5 cm in diameter at breast height; a standard suite of environmental information; and soil samples from several locations within the plot for chemical and textural analyses. All plot locations are recorded to within 5 m accuracy using a Global Positioning System (GPS) unit.

■41 At the beginning of the project, a stratified sampling plan was developed to place plots more or less evenly over the entire Virginia-side study area and across the full range of site conditions, including geologic substrate, aspect, and topographic position. This involved some reconnaissance in order to get a feel for these conditions and for vegetation patterns on the ground. Since our main objective was the classification of late-successional or persistent natural communities, sampling in this project was heavily biased to avoid early-successional forests and disturbed habitats such as clearings, roadsides, and areas over-run with introduced species. This slide shows the distribution of plots over an especially rugged part of the Gorge.

■42 This slide shows the general location of all 215 plots sampled over three field seasons. Sampling was fairly well dispersed, except in the stretch of private land around Chain Bridge, and in the very narrow and disturbed lower part of the Gorge. Many habitats of the Gorge exhibit pronounced seasonal variation in vegetation composition, which required that all plots be visited and species cover be recorded at least twice during the growing season.

■43 This and the next slide illustrate a type of seasonal variation that is widespread in the Gorge. This is a plot of the Riverbend floodplain in late April. As you can see, ramps (*Allium tricoccum*) and other spring ephemerals are very lush and abundant, and shrubs of paw-paw (*Asimina triloba*) are just leafing out.

■44 This slide shows a slightly different view of the same plot in late August. All the vernal species have evanesced for the year, and the cover of paw-paw is much higher. Although it's

hard to see in the photo, there are also a few fall-maturing species that have gained greater prominence.

■45 Comprehensive analyses have been conducted of the plot data, both in a discrete dataset and in a regional dataset for the National Capital Region parks project. Following a standard workflow, cluster analysis using the Lance-Williams Flexible-Beta linkage method and the Bray-Curtis coefficient of dissimilarity was first employed to identify groups of compositionally similar plots that potentially represent community types.

■46 Groups identified in cluster analysis were tested by generating compositional statistics that summarize the constancy, mean cover, fidelity, and relative cover of every species in a group under consideration. This procedure also calculates three types of synthetic diagnostic indicator values that provide numerical indications of a species' importance in the group. For example, in this group of floodplain forest plots, you can see that the silver maple (*Acer saccharinum*) occurs in every plot, has a very high mean cover per plot, averages four cover classes greater in this group than in the entire dataset, and has more than 50% of its occurrences in the dataset in this group. As a result, it has extremely high diagnostic indicator values and is clearly both a dominant and diagnostic species for the group. Likewise, boxelder (*Acer negundo*), false nettle (*Boehmeria cylindrica*), wood nettle (*Laportea canadensis*), and white snakeroot (*Ageratina altissima* var. *altissima*) all have high constancy and diagnostic values, and have been flagged as potential species that could be used to define this community. Two additional statistics – mean species richness, or the average number of species per plot, and homoteneity, a measure of how uniform the species composition is among plots – were also evaluated.

■47 You may recall that we also measured all the woody stems in the plot. This enables us to calculate the density and basal area per hectare of each species for each plot, or averaged for a group of plots. An importance value for each species is calculated by averaging relative density and relative basal area. This table shows the averages for the same group of floodplain forests we just looked at. You can see that silver maple and boxelder each have about the same average density of stems, but that most of the large trees are silver maple and most of the smaller trees are boxelder. These two species have by far the highest mean importance values in the group, which is consistent with the compositional statistics generated using cover values.

■48 Finally, non-metric multidimensional scaling (NMDS) ordination was applied to validate the classification and identify the environmental gradients along which vegetation types are distributed. This technique arranges vegetation samples in a multidimensional space based on compositional similarity and relative species-abundances. Unlike cluster analysis, which forces samples into hard-and-fast groups, ordination is able to display patterns of continuous variation in a dataset. Nevertheless, plots within a given group identified by cluster analysis should be positioned close to one another in ordination space. Another very valuable tool in ordination is the ability to display statistically significant correlations between environmental variables and the sample coordinates on each axis. For instance, in this ordination diagram plots of flood-scoured vegetation on the bedrock terraces are distributed in association with high values for exposed bedrock and moss/lichen surface cover.

■49 Typically in a project like this we'll run a series of ordination studies, starting with large groups and working down to smaller ones. This slide shows an ordination of upland forest community types. In this analysis, there are closely correlated topographic, moisture, and soil

fertility gradients running more or less vertically through the ordination space. Groups at the top are associated with high site moisture, high soil calcium, magnesium, total base saturation, and to a less extent other cations, while plots toward the bottom are located at the low end of these variables and at higher topographic positions with high soil iron levels. A secondary gradient runs SW-NE, with the plots on the upper right side of the diagram distributed in association with steeper slopes and high boulder cover.

■50 The taxonomy we use to define communities is hierarchical, as shown in this example. The "community type" is the finest level, analogous to the "species" level in plant taxonomy and defined by a specific association of characteristic plants. Community type associations are incorporated into a national classification system and assigned global and state rarity ranks by the Natural Heritage network based on criteria similar to those used to rank plant and animal species.

■51 If you would like a more detailed explanation, please visit our website, which has a fully illustrated version of the Virginia community classification and more information about the data collection and analysis protocols we use: http://www.dcr.virginia.gov/dnh/nchome.htm

■52 With the caveat that a few minor revisions may be required as the project is finalized, here are the major results of our analyses.

■53 First, a few general statistics. Of the 215 plots sampled, 175 were forested, and 40 represented shrubland or herbaceous vegetation. 767 vascular plant taxa were recorded in these plots, 84% of them indigenous and 16% introduced. The mean number of species per plot was about 51. According to The Nature Conservancy, 20% of all vascular taxa in the entire Gorge are introduced, so it seems that our dataset bias toward relatively undisturbed vegetation is reflected in these results. In the lower table, the Potomac Gorge data are compared with two other Northern Virginia sites that we have studied in a similar manner – the Bull Run Mountains and Shenandoah National Park. Even though the three projects involve areas of different geographic scale and unequal intensities in sampling, the comparison provides at least a rough indication of how diverse the Potomac Gorge is. Compared to the Bull Run Mountains, the Gorge is much richer floristically, has a much higher beta diversity, and has more than twice as many community types. It has fewer community types but a comparable beta diversity and almost as many plant taxa as Shenandoah National Park, which is noteworthy since the Shenandoah covers an area 100 times larger and spans a big elevation range on the Blue Ridge. The New River Gorge in West Virginia, which was studied intensively by the WVA Natural Heritage Program, is more diverse than the Potomac Gorge by most measures, although considerably larger.

■54 Virginia Creeper (*Parthenocissus quinquefolia*) is the most frequent species in the dataset, occurring as a ubiquitous, low-cover plant in a very wide variety of habitats. The two species that generally have the most abundant cover over the area are American beech (*Fagus grandifolia*) and paw-paw (*Asimina triloba*).

■55 We calculated the average density, basal area, and importance values of all woody species in the forested plots, and beech again emerged as the leading species. Tulip-poplar (*Liriodendron tulipifera*) and chestnut oak (*Quercus montana*) both have higher average basal area and density of large trees, but beech attains a higher importance value because of its tremendous density of small trees and saplings, second only to paw-paw.

■56 This is a table of the largest measured individuals of various tree species. A number of forests on the Virginia side of the Gorge have not been cut for 100 years or more and are now impressively mature. If you like big trees, these are good places to find them.

■57 The second largest individual measured in a plot is an American sycamore that is almost 1.5 meters in diameter and 42 meters tall.

■58 The Maryland side is also home to a number of very impressive individuals, like this Shumard Oak (*Quercus shumardii*) near Lock 7 on the C&O Canal.

■59 Now we will present a brief overview of most of the community types, starting with the upland forests. We will then cover communities of the bedrock terraces and outcrops, and finish with the riparian communities. Based on the regional data analysis we conducted for NCR parks, most of the Virginia-side types also occur on the Maryland side of the river. However, each side of the river has several types not found on the other side, and the shared community types also tend to occur in different proportions because of differences in topography.

■60 A mixed forest of beech, tulip-poplar, white and red oaks is by far the most common upland community type on the Virginia side of the Gorge. 19% of the upland forest plots, and 15% of the entire dataset, represent this type.

■61 This Mesic Mixed Hardwood Forest grows on mesic to dry-mesic slopes with well-drained, infertile, silt loam soils. This is a very common community type throughout the Piedmont region of both Virginia and Maryland.

■62 The herb layer of this forest is naturally patchy but can be very sparse in parts of the Gorge that have large deer populations. Christmas fern (*Polystichum acrostichoides*) and New York fern (*Thelypteris noveboracensis*) are two of the most abundant herbs in the type, in part because they are nearly immune to deer-grazing.

■63 Also widespread is a type of Basic Mesic Forest that occurs on somewhat more fertile slopes throughout the Gorge. This community has an overstory similar to that of the mesic mixed hardwood forest but usually has a dense understory of paw-paw and a relatively lush and diverse herb layer.

■64 This forest has several patch-dominant herbs, including spring-beauty (*Claytonia virginica*), maidenhair fern (*Adiantum pedatum*), perfoliate bellwort (*Uvularia perfoliata*), and black cohosh (*Cimicifuga racemosa*). Compared to the Mesic Mixed Hardwood forest, this type grows in silty soils with demonstrably higher pH, calcium, magnesium, manganese, and total base saturation levels.

■65 Large clones of may-apple (*Podophyllum peltatum*) are usually the best indicator of this type during the spring and early summer.

■66 The north-facing river bluffs in Scotts Run Nature Preserve and Turkey Run Park contain large intrusions of basic igneous rocks such as amphibolite, metagabbro, soapstone, and hornblend tonalite that weather into soils with a higher silt content and higher calcium and magnesium levels than other upland soils in the Gorge. The highly mesic and fertile ravines and

lower slopes of these bluffs support a second type of rich, mesophytic forest community. Like the previous type, this community has a luxuriant herb layer dominated largely by spring ephemerals. Two of the most abundant herbs are shown in the photo: blue cohosh (*Caulophyllum thalictroides*) and, beneath it, harbinger-of-spring (*Erigenia bulbosa*).

■67 This community has a mixed overstory of sugar maple (*Acer saccharum*), beech, tulip-poplar, basswood (*Tilia americana* var. *americana*), white ash (*Fraxinus americana*), and bitternut hickory (*Carya cordiformis*), with abundant paw-paw and spicebush (*Lindera benzoin*) in the understory. It has a distinctive herbaceous layer that contains a number of species not found in other upland forests of the area. Two of the locally abundant, and most diagnostic, of these are twinleaf (*Jeffersonia diphylla*) and toadshade trillium (*Trillium sessile*), which comes in red and yellow-flowered forms.

■68 A number of additional herbaceous species such as Dutchman's breeches (*Dicentra cucullaria*) and yellow trout-lily (*Erythronium americanum*) can also patch-dominate areas of the forest.

■69 In both Virginia and Maryland, this very rich community is most common on river-fronting limestone slopes of the Ridge and Valley province, but it finds favorable conditions on the most basic soils of Piedmont river valleys. The sites where it growns are the most productive habitats for spring wildflowers in the region.

■70 With wave after wave of flowering ephemerals as spring progresses, the emergence of spring in the Piedmont is nowhere more exemplary.

■71 Large areas on the Virginia bluffs of the Gorge are also covered by extensive deposits of loose boulders and stones that have weathered off outcrops of both the Mather Gorge and Sykesville Formations. Some of these boulderfields contain an abundance of mafic intrusive rocks. They support a distinctive forest community of plants capable of rooting deeply and thriving in limited pockets of interstitial soils between the rocks.

■72 Sugar maple, basswood and white ash are the principal trees, usually forming open stands that are subject to frequent windthrows because of difficult rooting conditions. Bladdernut is usually the most abundant and diagnostic shrub. Virginia creeper and other vines are common.

■73 Species richness and herb density are usually somewhat limited by high rock cover, but pale jewelweed (*Impatiens pallida*) is especially well adapted to these habitats and literally covers some boulderfields in the late summer.

■74 As far as vegetation sampling goes, boulderfields are often unpleasant and dangerous places with steep, unstable substrates and dense colonies of poison-ivy (*Toxicodendron radicans*).

■75 They are also characteristic habitats for the northern copperhead, which probably utilizes the piled boulders as hibernacula or at least as productive places to find prey such as chipmunks.

■76 A drier mixed hardwood forest with more oaks grows on steep, rocky, north-facing bluffs above the boulderfields in the middle and lower sections of the Gorge. Some of these habitats are too steep to walk or conduct plot sampling on. The composition of this type is distinctive in

that large-diameter chestnut oaks (*Quercus montana*) are nearly always conspicuous in the overstory, and the understory contains a diversity of species, including witch-hazel (*Hamamelis virginiana*), sugar maple (*Acer saccharum*), eastern hophornbeam (*Ostrya virginiana*), and wild hydrangea (*Hydrangea arborescens*).

■77 The herb layer is also distinctive, with dense populations of marginal woodfern (*Dryoteris marginalis*), white wood aster (*Aster divaricatus*), and several sedges. This community is a rich expression of a vegetation type that is much more common on central Appalachian mountain ridges.

■78 An oak-hickory community type is locally common on dryish, convex middle and upper slopes of the Gorge, usually occuring in small patches. The highest-quality and most extensive occurrences of this type are in Great Falls Park on the middle slopes along the west-facing side of Difficult Run.

■79 The lower layers of this community contain a very diverse mixture of dry-site grasses and herbs, as well as low shrubs such as maple-leaf viburnum (*Viburnum acerifolium*) and low-bush blueberry (*Vaccinium pallidum*). Species-richness can exceed 100 taxa in a 400 square meter plot. Although white oak (*Quercus alba*), black oak (*Quercus velutina*), pignut hickory (*Carya glabra*), and flowering dogwood (*Cornus florida*) are among the most diagnostic species of this type, beech and red maple (*Acer rubrum*) are often the most abundant understory trees, with densities up to 500 stems per hectare in some areas. In addition, recruitment of oaks is very poor on most sites, and the forest appears to be undergoing a gradual change toward dominance by more mesophytic species. Tragically, thousands of flowering dogwood stems in this forest have also recently succumbed to the fungal pathogen dogwood anthracnose.

■80 The invasion of oak forest understories by beech and maple is occurring throughout the Virginia Piedmont, and is especially noticeable in the winter, when young beech tends to hold onto its leaves. There is a compelling body of ecological research that points to the long-term reduction or exclusion of wildfires (both natural and human-caused) as the chief cause of this region-wide phenomenon. Even occasional low-intensity fires readily kill thin-barked tree species such as beech and red maple while providing optimal seedbed conditions for oak regeneration. Abrams and Copenheaver clearly documented this trend in their 250-year chronology of the old-age white oak forest at Great Falls. Management through prescribed burning could potentially restore fire as an ecological process, but it may not be feasible in a heavily developed area like the Potomac Gorge. As a result, it is likely that the oak-hickory forest community will gradually succeed to a beech-oak forest over time.

■81 A forest community dominated by the chestnut oak (*Quercus montana*) is characteristic of the highest and driest upland sites of the Gorge, including the sharply convex ridge crests and south to west-facing upper slopes.

■82 Although chestnut oak is usually dominant, scarlet oak (*Quercus coccinea*) is often a co-dominant or associate tree. Stands typically contain dense ericaceous shrub layers of mountain-laurel (*Kalmia latifolia*), black huckleberry (*Gaylussacia baccata*), and blueberries (*Vaccinium* spp.), and very few if any herbaceous species. This community has the lowest species-richness of any upland community type in the Gorge. Fire was almost certainly an important ecological influence in the past, but low site moisture and extremely infertile, silty-clay soils are now the

driving environmental factors. Because of its special adaptability to drought-prone habitats, this community is not likely to undergo rapid successional changes because of fire exclusion.

■83 Three interesting plants occur locally in stands of the chestnut oak forest community on the Virginia side of the Gorge. The montane disjunct table-mountain pine (*Pinus pungens*) grows in one spot near Dead Run in Turkey Run Park. Another largely montane plant, the great or rosebay rhododendron (*Rhododendron maximum*), persists among mountain-laurel on two very steep, north-facing slopes, where it was first documented by local botanists in the late 19th and early 20th centuries. Finally, the chestnut oak community contains most specimens of the American chestnut (*Castanea dentata*) that we have recorded during the project. The tree in the right photo is in Turkey Run Park at the same site where table-mountain pine grows.

■84 A forest community in which the eastern hemlock (*Tsuga canadensis*) is dominant or co-dominant formerly occurred on sheltered slopes along Scotts Run, Bullneck Run, and Difficult Run on the Virginia side of the Gorge. The photograph shows the Scotts Run site as it appeared about 25 years ago.

■85 Unfortunately, outbreaks of the hemlock woolly adelgid, a tiny aphid-like insect, have killed almost all hemlock at the Difficult Run site, and most of the large and medium-sized hemlocks at Scotts Run. Trees at the Bullneck Run site are currently in somewhat better shape. Formerly, this community was co-dominated by hemlock and chestnut oak, and was noteworthy in having the sweet birch (*Betula lenta*), which is somewhat of a mountain disjunct, as an associate tree at all sites. These sites are steep and rocky, and probably have cool microclimatic conditions induced by local topography and the large, high-gradient subtending streams.

■86 The next six community types are confined to the large bedrock terraces that extend interruptedly from Great Falls downstream to Madeira School, and more extensively on the Maryland side. The first two communities are unusual in that they are essentially upland vegetation types but are periodically scoured by catastrophic floods. This one is a dry forest of oaks, pignut hickory, and white ash occupying rocky flats that are impacted by catastrophic floods every 30-85 years on average.

■87 This dry oak-hickory forest has the highest species richness among the upland forests of the Gorge, averaging 93 species per plot. Woody diversity is very high and some of the most diagnostic plants in this type include post oak and the shrubs fringetree, hop tree, and downy arrow-wood.

■88 The herb layer is dominated by a number of characteristic grasses and sedges, several of which are shown in the slide. This community is considered rare globally and believed to be endemic to the Potomac Gorge. By far the largest patch of this community is on Bear Island, Maryland in the C&O Canal National Historical Park.

■89 Extremely xeric, rimrock areas of the terraces support an open woodland community dominated by the Virginia or scrub pine (*Pinus virginiana*). Eastern red cedar (*Juniperus virginiana* var. *virginiana*), stunted oaks, and various shrubs are associated.

■90 These rimrock habitats have extremely limited soil development, are scoured by floods every 12 to 30 years on average, and are subject to severe drought stress – all of which creates a situation conducive to Virginia pine regeneration and limiting to potential hardwood successors.

Although it hasn't been formally ranked, this community type is also likely to be very rare globally and is currently known only from the Potomac Gorge and the New River Gorge in West Virginia.

■91 This community is best developed and most extensive on the rim of Bear Island on the Maryland side of the Gorge.

■92 On the lower bedrock terrace shelves that flood at least once every seven years, a vegetation type dominated by several prairie grasses is characteristic. This "riverside prairie" usually has scattered, small, flood-battered trees, so the type is physiognomically referred to as "wooded herbaceous vegetation."

■93 The habitats supporting this community are somewhat xeric and contain pockets of very fertile alluvial soil deposits. Small pools and depressions with wetland species occur as frequent inclusions within the prairie.

■94 The most dominant species in all of the riverside prairies is big bluestem (*Andropogon gerardii*), although several other grasses and forbs are frequently co-dominant. However, this vegetation is extraordinarily diverse. The nine plots sampled on the Virginia side averaged 88 species per plot and four plots had more than 100 species.

■95 The wild blue indigo (*Baptisia australis*) and indian-grass (*Sorghastrum nutans*) are two other diagnostic species of this community type.

■96 This xeric riverside prairie was just recently classified during the NCR project. It appears to be extremely rare globally, with a distribution restricted to scoured outcrops along the Potomac and its major tributaries in Maryland and Virginia.

■97 This community differs from the more mesic and frequently flooded riverside prairies that occur on the channel shelf below Little Falls at Chain Bridge Flats and along many rivers in the mountain region of Virginia and West Virginia.

■98 Exposed, sparsely vegetated cliffs and outcrops in the Gorge support a community type that is aptly described as a Riverside Outcrop Barren. This community contains sparse vascular vegetation, with a few low shrubs and herbs occupying crevices and small soil or moss mats. A dwarfed form of the fetterbush (*Leucothoe racemosa*) is the most characteristic shrub.

■99 The two most numerous and characteristic herbs in this type are the little bluestem (*Schizachyrium scoparium*) and the sticky goldenrod (*Solidago racemosa*), which is not known outside the Potomac Gorge in either Virginia or Maryland. In the photo on the left, you can also see the blue-flowered stiff aster (*Ionactis linariifolius*), another frequent component of these barrens. These outcrops are scoured every one to 12 years on average and lack any true soil development. This community type is considered globally rare and is endemic to the Potomac Gorge as far as we know.

■100 Lichens are the prevalent biota of riverside outcrop barrens and the foliose species *Xanthoparmelia conspersa* is generally one of the most abundant and conspicuous.

■101 Riverside outcrops on public lands are very susceptible to degradation by over-visitation and trampling. In Great Falls Park, you can generally gauge the level of this kind of disturbance on a barren by how abundant crustose lichens are. *Grimmia laevigata*, a thick blackish-green moss that occurs on seasonally or ephemerally wet outcrop microhabitats, is also very vulnerable to heavy foot traffice and trampling.

■102 One of the most enigmatic communities in the Gorge is a dense shrubland co-dominated by American hornbeam (*Carpinus caroliniana*) and deciduous holly (*Ilex decidua*). We found only a single stand of this on the Virginia side of the river, but there are several on the flanks of Bear Island on the Maryland side.

■103 This community occupies the eroding sides and draws of bluffs and bedrock terraces that are flood-scoured every 1 to 15 years. So far, this type is known only from the Potomac Gorge and a smaller gorge on the Rappahannock River near Culpeper, Virginia. Between the rocky, flood-damaged habitats and the density of shrubs, this vegetation can be a real challenge to plot-sample.

■104 The last bedrock terrace community is a hydromorphic semi-aquatic type dominated by the spatterdock (*Nuphar advena*). On the Virginia side, this flooded pond vegetation occurs only on the margins of Black Pond at Madeira School. Very small patches also occur in pools and potholes on Bear Island across the river.

■105 The single plot sampled of this vegetation contained only four species, one of which was the invasive aquatic *Hydrilla verticillata*. Although spatterdock often occurs in artificial water bodies, this bedrock terrace pond is likely to be a very rare natural community type.

■106 Along several streams of the study area are flat sites saturated by groundwater seeping from the base of adjacent slopes. These habitats support a community type that's often referred to as a "seepage swamp," and it is the only non-alluvial wetland occurring in the Gorge. In the early part of the growing season, dense colonies of the skunk-cabbage (*Symplocarpus foetidus*) immediately distinguish this community on the landscape.

■107 The overstory of this wetland forest is dominated by red maple but also usually contains green or white ash (*Fraxinus pennsylvanica* or *F. americana*). Winterberry (*Ilex verticillata*) is the most diagnostic shrub, and several ferns are also characteristic.

■108 This community exhibits very pronounced seasonal variation in composition, with skunk-cabbage overwhelmingly dominant from early spring to about late June.

■109 As summer progresses, skunk-cabbage dies back and these swamps usually become covered by lizard's-tail (*Saururus cernuus*) during the second half of the season.

■110 With this slide, we begin an overview of riparian or floodplain communities. The principal riparian forest community on more stabilized river banks and the lowest floodplain terraces has strong dominance by silver maple (*Acer saccharinum*) in the overstory and by boxelder (*Acer negundo*) in a slightly shorter understory. This community type occurs only in the lower-gradient sections of the Gorge, is flooded very frequently, and grows in loamy sands that are among the most fertile soils in the whole dataset.

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■112 The herb layer consists largely of colonial perennial species that are tolerant of periods of inundation and capable of maturing quickly when soils dry out. Wood nettle (*Laportea canadensis*) and white snakeroot (*Ageratina altissima* var. *altissima*), along with several wild rye species (*Elymus* spp.), are probably the most characteristic herbs. Eastern cottonwood (*Populus deltoides*) is a minor tree associate, but occurs more often in this community than in other types.

■113 A more mixed and very lush forest community grows on the slightly higher and less frequently inundated floodplain terraces. In the spring, this type can be distinguished by its massive colonies of Virginia bluebells (*Mertensia virginica*) and other nutrient-demanding forbs.

■114 The tree layers of this type contain sycamore (*Platanus occidentalis*), boxelder, black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), and sometimes tulip-poplar and Shumard oak (*Quercus shumardii*). Paw-paw and spicebush form a dense shrub layer. Some of the most diagnostic herbs in Potomac Gorge stands include white trout-lily (*Erythronium albidum*), wild ginger (*Asarum canadense*), and wild blue phlox (*Phlox divaricata*).

■115 However, the Canada waterleaf (*Hydrophyllum canadense*) is second only to bluebells in abundance and often forms equally large dominance patches. The fertile soils in which this floodplain forest grows include both sandy loams and silt loams.

■116 The remainder of the riparian communities are spatially, temporally, and compositionally dynamic vegetation assemblages that occupy frequently flood-disturbed habitats on the channel shelf. Rocky, seasonally exposed shores at the lowest relative elevations of the shelf are overwhelmingly dominated by *Justicia americana*, the water-willow. These cover many hectares along the river margin and stay flooded for long periods of the growing season.

■117 The soils that were collected with difficulty from these rocky habitats had pHs up to 7.6 and exceptionally high calcium levels, which is testimony to all the rich alluvium that has washed down the Potomac from the Shenandoah Valley and other limestone areas. The species richness of water-willow stands is very low, and the halberd-leaved rose-mallow (*Hibiscus laevis*) in a dwarfed form is one of the few associates that seems to occur regularly.

■118 A low herbaceous communtiy type occupies fine-textured, sand or silt depositional bars and low river banks that are seasonally exposed during low flows from mid-summer to early fall. This very distinct environment selects for opportunistic, non-competitive annuals which produce seed banks tolerant of prolonged inundation and which can grow and reproduce quickly when habitats are exposed.

■119 This vegetation usually occurs in small, often linear patches and can have the appearance of a “lawn” when well developed. The fine alluvial soils on these bars have very high fertility, and the low vegetation is surprisingly diverse, averaging 50 species in a 100 square meter plot.

■120 The creeping lovegrass (*Eragrostis hypnoides*), false-pimpernel (*Lindernia dubia* var. *dubia*), and awned flatsedge (*Cyperus squarrosus*) are three of the most characteristic and abundant annuals in this community.

■121 Slightly higher sand and silt bars that are exposed for more of the growing season support a tall herbaceous community. This can occupy a linear zone adjacent to and higher than the low herbaceous shore, as shown in this slide.

■122 It can also cover larger areas, with late thoroughwort (*Eupatorium serotinum*) usually the dominant species. There is much more habitat for this community on the Maryland side of the river, and large areas there are suffused with white when the thoroughwort is in flower.

■123 The most characteristic species on these tall herbaceous bars are weedy, fast-growing annuals and perennials that are adapted to frequent sediment turnover during large floods.

■124 Higher and more stabilized rocky and cobbly bars support scrubby woodland vegetation typically dominated by American sycamore and river birch (*Betula nigra*). This community type varies greatly in physiognomy, with structures ranging from that of a shrubland to that of an open forest.

■125 These habitats are typically flooded once or more a year and can be significantly altered by large floods and ice-scouring. The overstory trees almost always exhibit mechanical damaage and flood-training, with leaning boles and numerous water sprouts.

■126 This slide shows a good example of how repeated flood impacts shape the physiognomy of the type. The photo also shows the typically stony substrate, with soils packed intersticially between the cobbles. Although the herb layer appears sparse, it's actually quite diverse, averaging 63 species in a 400 square meter plot.

■127 The final community is the most floristically diverse on the Virginia side of the Gorge. It is a mixed deciduous woodland of several floodplain trees that occupies the active channel shelf in areas dominated by bedrock outcrops. There is precious little of this habitat on the Virginia side of the Gorge, but larger stands occur on the Maryland and D.C. side, especially on Chain Bridge Flats. In Virginia, I've found this type mainly in an area just above Great Falls, with smaller patches at Riverbend and Turkey Run.

■128 Although these habitats have a lot of rock cover, they also tend to have heterogeneous microtopography, with pockets of deep soil deposition, depressed channels, and even small pools. As in the sycamore-river birch woodland, the trees in this vegetation are very susceptible to uprooting and mechanical damage, which maintains an open woodland physiognomy. The combination of variable microhabitats, good illumination, and very fertile soils fosters incredible species richness. The four plots we sampled had an average of 111 vascular taxa, with one plot containing 130 taxa, the highest number recorded in more than 3600 plots sampled by the Virginia Natural Heritage Program since 1990.

■129 Changes in this woodland and its habitat over a full growing season are dramatic. This slide shows the plot at Turkey Run Park that contained 130 taxa in high water of early spring.

■130 A short time later, the flow has receded, exposing the bedrock floodplain.

■131 And this is what the same area looks like in its full, late-summer development.

■132 In the Gorge, clones of the sedge Carex emoryi are usually good indicators of this community type.

■133 This slide briefly summarizes the major threats to natural communities that are reflected by the plot data. The two pervasive or widely manifesting threats are excessive herbivory by deer and invasive introduced plants. White-tailed deer have become increasingly overabundant in northern Virginia since about 1980, and the Gorge is no exception. About 50% of our plots had major deer artifacts, but we will have more to report about this issue once additional data analysis is completed. Local area threats that were apparent only in a small subset of plots include several insect and fungal pathogens, damage to vegetation from by Park visitors, and fire exclusion, most of which have already been mentioned.

■134 Invasive introduced plants are the leading threats to native vegetation in the Gorge. Because sampling in this project was biased to avoid heavily disturbed areas, the plot data do not accurately represent the overall status of invasives in the Gorge. They do indicate, however, the species that are most widespread and problematic in the least disturbed forest vegetation. These species are listed on the slide in descending order of frequency. Any of the top tier of this list are fully capable of eliminating most native species from the forest floor over time.

■135 Although garlic-mustard (*Alliaria petiolata*) has the highest frequency and mean abundance among invasives in our plots, stilt-grass (*Microstegium vimineum*) is the most aggressive and rapidly spreading invasive everywhere in Virginia today. Twenty-five years ago, this grass was uncommon and localized in northern Virginia. Since then, the speed and extent to which it has spread are unprecedented among contemporary invasives in the region.

■136 Because of the urban settings, there are any number of exotics that have become prolific over discrete areas. English ivy (*Hedera helix*) and bamboo (*Phyllostachys* sp.) are two examples.

■137 In the Potomac Gorge, there are also a number of what could be called “emerging exotics” that are spreading rampantly from urban plantings but that have not yet appeared widely in Virginia. The winter-flowering cherry (Prunus subhirtella) and the linden arrowwood (Viburnum dilatatum) belong to this group and have the potential to become terribly invasive in undisturbed forests, based on what we have seen.

■138 We will close this presentation by returning to the idea of community inventory as a “coarse filter” approach to conservation. How well have we done so far in this project? To crudely answer it, we first went through the entire Virginia flora and all available records for the Gorge and came up with a liberal estimate of about 1100 vascular plant taxa that have been documented or could potentially occur on the Virginia side. If this is correct, our plots captured 70% of this flora. There’s no doubt that an intensive, conventional floristic study would capture more, but 70% is quite respectable considering that all the plots together cover an area less than 8 hectares, or about one-half of 1% of the study area. And we also got a great return on our investment in plot sampling, with extensive quantitative data on the frequency, abundance, habitats, soils, and associated vegetation of each species that never would have been collected in a conventional flora.

Next we assembled a list of all the rare and watchlist species known from the Virginia side of the Gorge. We eliminated 15 species that haven’t been seen in more than 50 years, and that likely no longer occur in the area. Of the remaining 36 species of conservation concern that

have been seen in the past 50 years, 28 (or 78%) were captured in plots, most of them multiple times.

■139 This slide shows the second half of the rare species table. Again, a conventional rare species inventory would likely do better, but this approach provides complementary information that can help quantify the community affiliations and environmental conditions under which rare species co-occur. Overall, we hope we have convinced you that the inventory of natural communities provides a good "filter" for capturing the biodiversity of an area and that it complements the standard types of floristic inventories you are probably familiar with.

■140 And that concludes the presentation. We would like to encourage everybody to support initiatives by The Nature Conservancy, the Potomac Conservancy, the National Park Service, and the Fairfax County Park Authority to protect this unusual natural area. The Potomac Gorge is truly an exceptional natural area and worthy of strong efforts to conserve its biodiversity for future generations.