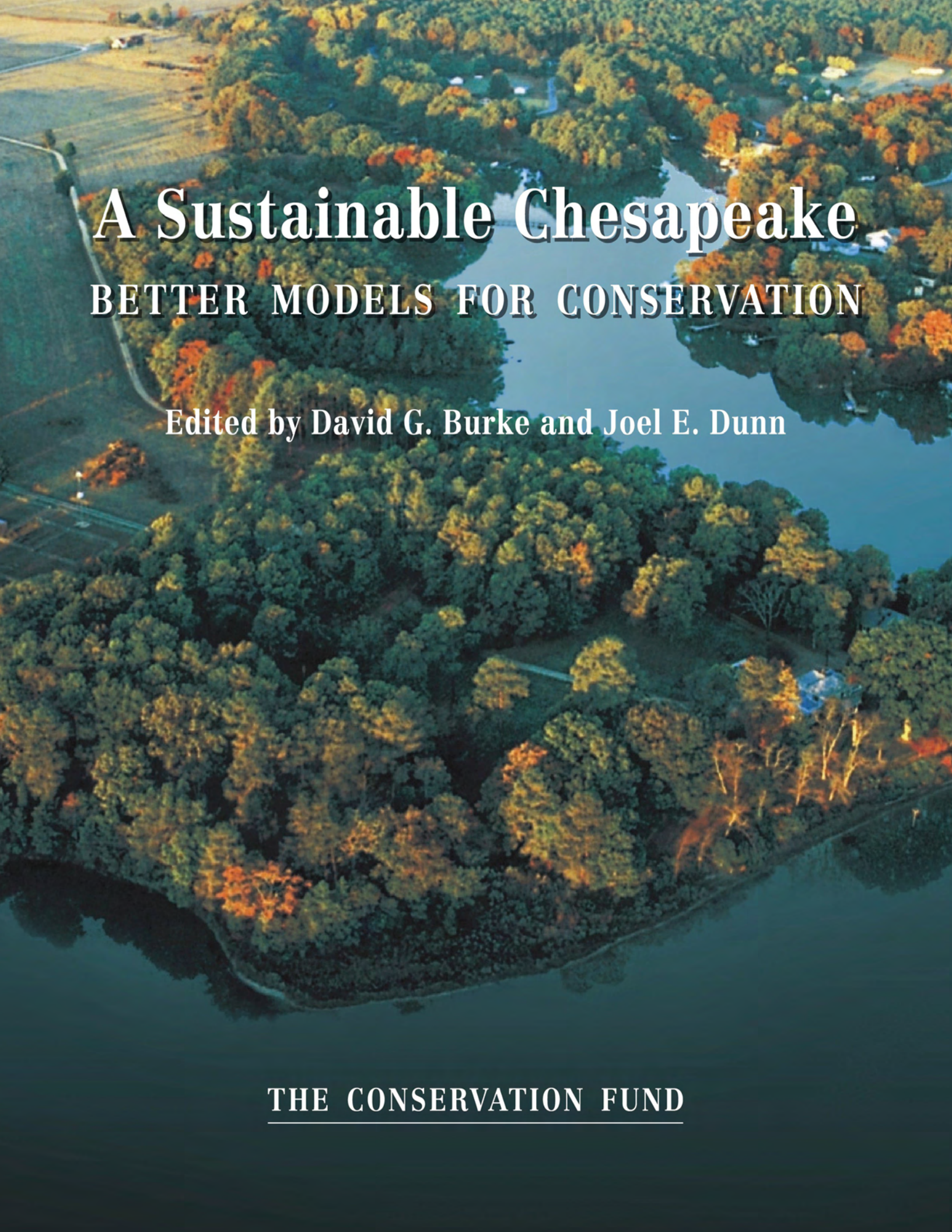

A Sustainable Chesapeake

BETTER MODELS FOR CONSERVATION

Edited by David G. Burke and Joel E. Dunn

THE CONSERVATION FUND

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CHAPTER 6

Stewardship

Stewardship
Introduction

Restoring the Chesapeake Bay watershed requires active engagement in the responsible management of natural resources. This conservation ethic is commonly called environmental stewardship.

Stewardship involves the vigilant awareness and care of citizens, organizations and governments that believe they share a common responsibility for the integrity of the natural world. Stewardship and community involvement have fueled awareness, appreciation and a demand for ecosystem restoration in the Bay region. On a local level, environmental stewards are actively involved in practices that collectively contribute to the health of the Chesapeake Bay watershed. Restoring and maintaining a vibrant Chesapeake Bay may not be possible until a majority of citizens are willing to invest time, energy and money in leading more sustainable lifestyles to help meet this critical challenge.

The case studies in this chapter were chosen to show how effective environmental stewardship actions can occur on farms, subdivisions, corporate lands, military bases, parks, refuges and other settings. The studies demonstrate successful practices that can be applied to the management of forests, wetlands, agricultural lands, water and invasive species. Hull Springs Farm used stewardship plans to create a sustainable farm operation and learning center. Fox Haven Farm restored overworked farmlands to enhance biodiversity. Duvall Farm used the U.S. Department of Agriculture's (USDA) conservation programs to improve local water quality and protect waterfowl populations. Philip Morris used engineered wetlands to reduce harmful pollutants in processed wastewater. The U.S. Navy implemented a sustainable infrastructure policy that included practical steps to retrofit stormwater management facilities. The Anacostia Watershed Society engaged volunteers to hand remove exotic invasive plant species from urban parks and the Eastern Neck National Wildlife Refuge used integrated vegetation management techniques to control invasive plants and restore native biodiversity and habitat.

Some of the principles underlying these successful stewardship programs, which are essential to attaining a sustainable Chesapeake, include:

- **Review and realign land management plans and practices at regular intervals to incorporate sustainability measures:** Scientists, researchers and field practitioners are constantly discovering new and better ways to manage land that employ less energy intensive methods, reduce life cycle operating costs, improve environmental performance and yield better results. Whether the land is being used to grow a lawn, produce farm products or manage a forest, regular consultations with experts that share a concern for sustainable management practices should be conducted to develop robust stewardship plans.
- **Harness biological processes to reduce pollution, benefit wildlife and people:** Native plants and the natural biological functions they perform are a practical, low cost, enduring solution to a wide array of watershed problems. There are many circumstances where vegetative solutions can be readily incorporated into terrestrial and aquatic environments or artificially engineered systems to remove or reduce pollutants, stabilize eroding landscapes, improve air quality, shelter wildlife and provide aesthetic and recreational benefits to people.
- **Maintain native flora and associated biodiversity:** Increased commerce and mobility of people across the planet has caused the introduction of numerous invasive exotic plant and animal species that have disrupted and, in many instances, irretrievably altered native ecosystems. Maintaining native flora requires an active effort to remove invasive species. Native plant communities are critical to keeping diverse, sustainable landscapes that support naturally adapted plant communities and associated wildlife.

Hull Springs Farm of Longwood University

Using Stewardship Plans to Create a Sustainable Conservation Model on Virginia's Northern Neck

In their quest to develop a model farm operation and learning center, Longwood University Foundation is using an adaptive management approach guided by comprehensive stewardship plans to help their students and interested citizens discover opportunities for creating a more sustainable planet.

CASE STUDY SUMMARY

Hull Springs Farm has a long agricultural history, but new natural resource conservation goals are taking it far beyond the traditional concepts of farming. Longwood University Foundation is transitioning the farm into an economically self-sufficient model of sustainability, conservation and land stewardship. Integral to the transition process is the opportunity for the University and local residents to experience a special place for the exploration of new and emerging environmental sustainability practices; interdisciplinary academic exchanges; and the transfer of knowledge needed to advance stewardship of rural working lands. Using grants and donated services, the Foundation has surveyed and restored their shoreline, inventoried and designed forest management strategies, developed plans for a 213 acre wetland mitigation site, and educated many students about sustainable environmental practices. Hull Springs Farms is a model for environmentally-sound land management and shows how other institutions across the Bay region can manage their lands in a sustainable manner.

Mary Farley Ames Lee, a 1938 graduate of Longwood University (then known as the State Teachers College), bequeathed Hull Springs Farm to the Longwood University Foundation, Inc., in 1999 to protect the property from development. The 662 acre farm in Westmoreland County, Virginia, was cultivated for hundreds of years to produce corn, soybeans, timber and other crops. It is situated on Virginia's Northern Neck between Aimes Creek and Glebe Creek, both tributaries of the Potomac River, just a short distance from the Chesapeake Bay. The property has approximately 8,400 feet of tidal shoreline and offers stunning views of Lower Machodoc Creek, wildlife, forests and open land. With 160 acres in agricultural fields and more than 400 acres in forest, it is an excellent demonstration site to develop, apply and study replicable best management practices.

In 2005, the Foundation started re-engineering Hull Springs Farm from a traditional working farm and timber operation to a sustainable model of conservation. Bobbie Burton, Executive Director and Katie Register, Program Director are working closely with the Hull Springs Farm Foundation Board of Directors, Longwood University faculty and a number of consultants, partners and advisors to produce stewardship plans for shoreline, forests, agricultural operations, buildings, wetlands, wildlife habitat and riparian buffers. Implementation of the plans will position the farm as the Northern Neck's premier multi-dimensional sustainable applications demonstration and learning center.

To date, the Foundation has implemented major components of their living shorelines stewardship plan and initiated plans for their built infrastructure, forest stewardship, wildlife habitat and wetlands mitigation bank. The Foundation's signature living shorelines project has effectively halted shoreline erosion and created a biologically diverse marsh that is now used as an important teaching tool for area residents and Longwood stu-

dents. Soon, the wetland mitigation bank will generate revenue for the farm while showing landowners that wetland restoration can bring financial as well as ecological benefits.

RESOURCE MANAGEMENT CHALLENGE

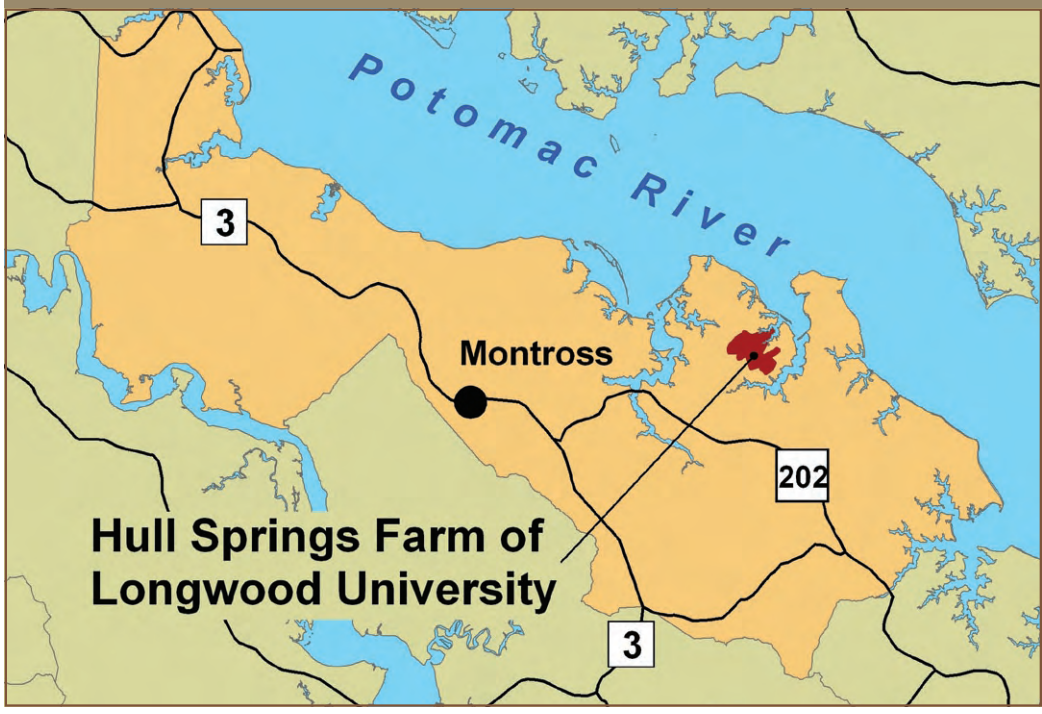
The land use history of Hull Springs Farm is typical of the entire Northern Neck peninsula. Before English settlement the land was composed primarily of forest and wetlands. In the 1700s, vast tracts of land were cleared, primarily for the cultivation of tobacco. These lands and the crops they produced supported the development of a unique culture whose residents have strong ties to their heritage, history and environment. Agricultural production and other factors resulted in non-point source pollution and habitat loss, which pose several natural resource management challenges for Hull Springs Farm.

Shoreline and wetland management at the farm has historically been a haphazard endeavor. Hull Springs Farm's shoreline is subject to heavy rates of erosion from rising sea levels and increased intensity of storms. Ceramic chimney tiles, a concrete seawall, and bamboo were used by previous owners of Hull Springs Farm in an effort to protect the shoreline from erosion, which damaged shallow water and tidal wetland habitat. Non-tidal wetlands on the property were drained for agricultural production, significantly reducing their acreage and functional characteristics. In the past farmers sought to increase crop production by draining wet fields through subsurface tile systems or ditches. At Hull Springs Farm these practices resulted in a significant loss of native wetland plant communities with species such as Atlantic white cedar (*Chamaecyparis thyoides*) and bald cypress (*Taxodium distichum*). The restoration of wetlands and shoreline and their associated ecological communities is important for the maintenance of water quality and biodiversity.

Forestry and invasive species management at the farm require long term planning. Forestry continues to be an important source of revenue for Hull Springs Farm, but the historical and typical method of harvesting trees at the farm was clear cutting. There are many potential negative impacts of clear cutting trees, such as runoff, erosion and habitat destruction. The farm needed a Forest Stewardship Management Plan that incorporates sustainable strategies for demonstration of forestry and habitat management as well as timber production for income. Invasive exotic species are a relatively minor concern at Hull Springs Farm, but the farm's forest and wetlands have patches of the tree-of-heaven (*Ailanthus altissima*), the common reed (*Phragmites australis*), known as *Phragmites*, and bamboo species. Invasive exotic species destroy natural habitat, can suppress the growth of young trees and are a major threat to biodiversity. They can also be very costly to eradicate once firmly established. Removing these species from Hull Springs Farm poses a difficult but manageable challenge.

Agriculture and aging wastewater infrastructure are the most significant sources of non-point source pollution to the surrounding creeks. Hull Springs Farm's agricultural fields have been in a corn/soybean crop rotation for many years, which typically require heavy inputs of manure or fertilizer, potentially adding nitrogen and phosphorus to the local surface waters and eventually the Chesapeake Bay. Although the farmer who leases the fields is required to use Best Management Practices, there are still many improvements that can be made to reduce pollution and demonstrate sustainable and innovative agricultural practices. The farm has several aging septic systems that,

Hull Springs Farm of Longwood University Location Map



Virginia Institute of Marine Science shore erosion control experts survey the Hull Springs Farm shoreline to develop a shoreline management plan. The area above shows an unorthodox management strategy used by the former owners to stabilize the shoreline using ceramic chimney tiles (vertical blocks at shoreline) and exotic bamboo plants on the steeply sloped bank.

in spite of routine maintenance and repairs, will need to be upgraded with nutrient removal technology. Organic waste contains nitrogen, phosphorus and disease-causing bacteria, such as *Escherichia coli* that contaminate shellfish beds. Hull Springs Farm is investigating innovative on-site wastewater management systems and enhanced riparian buffer systems.

Many Northern Neck land owners and managers have deep commitments to some of the traditional agricultural, forestry, and other land management practices. One of Hull Spring Farm's biggest challenges is to find new ways for area residents to manage the land and show them how it can be done without affecting their revenue.

CONSERVATION VISION

Mary Farley Ames Lee lived at Hull Springs Farm and watched as the land across the creek and around the farm was subdivided and developed. She watched as the natural shorelines of trees and shrubs gave way to seawalls, revetments and fescue lawns mowed to the water's edge. She was keenly aware of the increasing degradation of the Chesapeake Bay and the declining numbers of watermen whom she had grown up watching. Mary donated Hull Springs Farm to Longwood University Foundation, Inc., on the condition that it not be subdivided for commercial or residential purposes and that it be used only for agriculture, archaeology, forestry, natural resource conservation, and educational purposes.

In accordance with Mary's conservation vision, Hull Springs Farm will be managed and developed as a compelling model of conservation and stewardship, where Longwood University students and the greater community can discover the opportunities, roles and responsibilities involved with creating a more sustainable planet. To move this vision forward, the management of Hull Springs Farm is now guided by the following principles for day-to-day operations:

- Fostering collaborative partnerships in the environmental community and beyond
- Implementing stewardship plans that lead to an *integrated* model of conservation
- Improving and expanding the capacity to host and deliver educational programs
- Establishing sustainability programs featuring the resources and practices at the farm
- Ensuring the long term financial stability of the farm

IMPLEMENTATION RESOURCES

Base Funding: Mary Farley Ames Lee left a modest operating endowment for the farm. In a good market, that endowment generates approximately $60,000 a year which covers the cost of a caretaker for the property, a small education fund, utility bills, and some maintenance expenses. Longwood University Foundation, Inc., uses other sources to provide funding for an executive director and limited office operating expenses. User fees from occasional rental of the residential buildings help to fund other maintenance costs.

Revenue Generated from Natural Resources: Some expenses are covered from use of the land. Leasing of the agricultural fields provides enough income to satisfy the local property taxes. Occasional timber cutting provides funding for facility improvements. When fully operational the wetland mitigation bank has the potential to generate substantial funding for the endowment and programmatic development. Wildlife habitat and conservation incentive programs that provide cost share assistance are being researched to assist with implementation of best management practices, demonstration projects and educational programming.

Grants and Private Support: The Jesse Ball DuPont Fund and the Blue Moon Fund provided the initial

funding for a feasibility study and subsequently a condition assessment of the buildings and updated survey of property. Funding through the National Oceanic and Atmospheric Administration (NOAA), the National Fish and Wildlife Foundation (NFWF), The Keith Campbell Foundation for the Environment and the Chesapeake Bay Trust have helped to establish an award-winning living shoreline demonstration site. Relatively small grants from various private foundations, individual gifts, workshop registration fees and in-kind donations of time and assistance provide a base for programmatic development.

Conservation Partners and Technical Assistance: Many have contributed to the successes at Hull Springs Farm to date. The in-kind contributions of individuals, government agencies, educational institutions and non-profit organizations have supported development of Hull Springs Farm as a model of conservation. Some important partners include: Burke Environmental Associates, the Virginia Institute of Marine Science (VIMS), the Department of Forest Resources and Environmental Conservation at Virginia Tech, Northern Neck Planning District Commission (NNPDC), Northern Neck Soil and Water Conservation District, Clean Virginia Waterways, the Virginia Departments of Environmental Quality, Forestry, and Conservation and Recreation, U.S. Army Corp of Engineers and blueskies environmental associates, inc. Volunteers were used extensively in marsh grass planting for the living shoreline areas.

CONSERVATION STRATEGY

The Foundation based its Hull Springs Farm conservation strategy on the development and demonstration of comprehensive, integrated stewardship plans for their agricultural operations, forests, shorelines, wetlands, riparian areas and wildlife. To oversee the process, the Longwood University Faculty Advisory Council and the Natural Resources Advisory Council were formed to set forth key environmental and educational objectives and to assist with resource planning and management issues. The Faculty Advisory Council consists of representatives from each of the University's three colleges, key departments and student activity programs. The Natural Resources Advisory Council consists of senior level representatives from core partners, relevant state and local agencies, and consultants.

A critical first step taken by the Longwood University Foundation, Inc. was the decision to conduct an initial feasibility study to determine how Hull Springs Farm could best serve various populations within Longwood University, Virginia's Northern Neck, and other educational institutions in the Chesapeake Bay watershed. The study provided an excellent overview of the issues, potential problems and opportunities associated with the new task of managing the donated Hull Springs Farm property.

Stewardship Plans: The Executive and Program Directors at Hull Springs Farm put a great deal of effort into securing the resources and appropriate expertise needed to compile detailed stewardship plans. The plans are very different in scope, detail and format from one another—reflecting the varied groups who worked on them, consisting of faculty members, students and consultants, and the resources at their disposal. Typically the teams' efforts were relatively low cost, done through in-kind resources and foundation grants. Normally, each topic area addressed within the planning process included a resource assessment and inventory, initial management scenario and a recommended plan. These efforts were summarized into two overall management plan maps showing terrestrial and aquatic elements derived from the teams work.

A notable addition to some of the stewardship planning elements was the inclusion of an evaluation and monitoring component to evaluate the project results, measure environmental indicators and communicate the findings to others. The stewardship plan development and implementation process at Hull Springs Farm is, by design, a work in progress that will follow the adaptive management model. This model is based upon the belief that effective resource management strategies evolve over time and are rarely successful during the initial phases. Instead, managers iteratively learn from each stewardship action and readjust their approach after the results are measured and evaluated against stated objectives. The stewardship initiatives undertaken by the Foundation are briefly catalogued below.

Shoreline Management: In 2005 and 2006, Hull Springs Farm launched *Living Shorelines: Shoreline Erosion Control and Habitat Enhancement Research Project* with many partners including VIMS, Burke Environmental Associates, NNPDC and others. The assessment and inventory phase of this project evaluated how living shoreline techniques could be used to control erosion, and preserve or restore shoreline habitat that supports shorebirds, juvenile fish, tidal marsh, submerged aquatic vegetation, and other plant and wildlife species.

The living shoreline stewardship plan addressed shoreline restoration and conservation options for Hull Springs Farm and all of the Lower Machodoc Creek. It also detailed the steps the Foundation needed to take to obtain permits for a living shoreline sill and marsh project. The project

The living shorelines project at Hull Springs Farm was installed to repair bank erosion resulting from the remnants of hurricane Ernesto that reached the North Carolina/Virginia border in 2006 as an extratropical cyclone.

protected the main residence and a champion 400 year old southern red oak tree (*Quercus falcata*) at the top of the bank. A low wall of rocks was installed in shallow waters to absorb wave energy and an 8,000 square foot tidal fringe marsh was planted in fill sand placed between the sill and toe of the bank. Earth Resources Inc. and volunteers subsequently installed the sill and marsh, and planted 4,800 plugs of marsh grasses (*Spartina alterniflora* and *Spartina patens*). The project used proven strategies and experimental technologies to protect the bank and enhance shoreline habitat.

A ten-year monitoring plan was set for the sill and marsh that includes warm-weather and cold-weather sampling of a wide range of organisms, including benthic-dwelling worms, fish, crabs, and snails. Monitoring also includes basic water quality parameters, terrestrial factors and the build-up of organic material in the fringe marsh over time.

Wetlands: In an effort to assess and inventory the past extent of wetlands on the property, soil and wetland scientists from VIMS installed monitoring wells to record water table data as part of their research of the hydrology, soil, and biological indicators to determine areas of the farm appropriate for restoration, enhancement or preservation as wetlands. Existing wetlands on the property were also delineated.

Working closely with Hull Springs Farm and VIMS, a consulting firm, blueskies environmental associates, inc. is close to finishing a stewardship plan that will outline the steps needed to establish a 213 acre wetland mitigation bank. The wetland mitigation bank will carry a permanent conservation easement. Once approved by federal and state agencies, the wetland mitigation bank will result in a combination of restored, enhanced and protected wetlands on Hull Springs Farm, as well as provide educational and research opportunities. The farm is planning to sell mitigation credits on a case-by-case basis and use the funds to operate the facility in accordance with its mission.

Forestry: Shortly after Longwood received Hull Springs Farm, it was apparent that management goals for approximately 400 acres of forestland were needed. Prior managers of the farm focused only on revenue generation, while new management saw the forested tracts as having potential for wildlife habitat, research locations, and education, as well as a source of revenue. Before determining what to harvest, what to preserve, and what to modify for educational purposes, the farm conducted a thorough inventory and assessment of biotic and abiotic factors, including: current forest conditions, plant species composition, and soil types; as well as other parameters such as access to sites and adjacent landowners.

Hull Springs Farm then worked collaboratively with professors and graduate students at Virginia Polytechnical Institute and State University (Virginia Tech) to develop a new Forest Stewardship Management Plan based on innovative applications of cutting-edge research. The plan calls for several demonstration plots to create varied environmental conditions, so differences in habitat use could be studied. The plan incorporates new directions in forest and wildlife management. The systems employed may include: natural regeneration (leave tree, shelterwood, seed tree, group selection and single tree selection); prescribed burning; successional models; intensive management; timber production for revenue; wildlife habitat practices; invasive species management; and reintroduction of Atlantic white cedar and bald cypress. The establishment of an Atlantic white cedar community is a significant ecological endeavor and will showcase a community that may have been present when the first European settlers arrived here.

Agriculture: The crop land (approximately 160 acres) at Hull Springs Farm is leased to a local farmer who practices no-till farming methods and plants a soybean-corn rotation with barley as a winter cover crop. He also uses Best Management Practices to protect water quality, soil productivity, and watershed health, and maintains an ongoing nutrient management program that includes

soils tests. The lease prohibits the use of sludge-derived fertilizer or biosolids. Some of the agricultural fields will be restored to forested wetlands in 2010-2011. A formal stewardship plan will be completed after implementation of the forest and wetlands plans. Longer-term plans for the remaining agricultural fields will include sustainable agricultural practices and possibly organic farming. Future plans for the agricultural fields include considering programs that offer cost-sharing funds from the U.S. Department of Agriculture (USDA), including the Conservation Reserve Enhancement Program (CREP) and Wildlife Habitat Incentives Program (WHIP).

Buildings: There are ten buildings at Hull Springs Farm of various ages. The condition of each was assessed by a professional engineering firm. A building stewardship plan is in development by the University that will include recommendations for renovation and maintenance of the ten Hull Springs Farm buildings. As funding becomes available, buildings will be renovated and new structures added to support educational programming using green building principles. Renovations and new construction will be designed so that a typical homeowner could reasonably replicate more sustainable building practices.

Education and Outreach: A portion of the initial feasibility study done for the farm assessed the environmental education and research needs of Longwood University, Virginia's Northern Neck, and the wider Chesapeake Bay watershed. While this plan is not fully developed, it is recognized that the Hull Springs Farm stewardship plans are important components of future education messaging. Through demonstration sites and hands-on activities, students and citizens will become better equipped to live sustainable lives, run sustainable businesses, and transmit their knowledge to others.

Other Stewardship Plans: The management team will complete stewardship plans for its riparian buffers, wildlife corridors and ponds after implementation of the shoreline, forest and wetlands plans. Meetings have been held with staff of the Virginia Coastal Zone Management Program to discuss the need for integrated shoreline management including land use, riparian and shoreline plans to foster healthy aquatic environments. In addition to addressing typical riparian buffers, attention will be directed to wildlife corridors and passageways throughout the property.

RESULTS

Although the Foundation's work is only in the formative stages of transitioning the property from a typical working farm to a model of conservation (see management plan maps), there are several notable accomplishments to date.

Partnerships: Staff and members of the board of directors have built a network of talented people and organizations to make Hull Springs Farm a model of conservation. Citizen volunteers, students and faculty perform many useful tasks, such as surveying wildlife populations and species lists for birds, reptiles, and bats.

Fundraising: Since the original bequest of the gift of Hull Springs Farm to Longwood University Foundation, Inc., $396,000 was raised from 26 individual donors, 7 private foundations, 1 corporation and 3 government grants.

Shoreline: Twenty-three miles of Lower Machodoc Creek were surveyed and classified for appropriate living shoreline technologies and a website was developed to inform landowners along those shorelines about the recommendations for their property.[1] The farm installed a sill along with a new 8,000 square foot tidal fringe marsh wetlands. This installation has won a regional and statewide award, and has been featured in the 2006 Maryland/Virginia Living Shorelines Summit as a case study, and other reports, presentations and papers by VIMS.

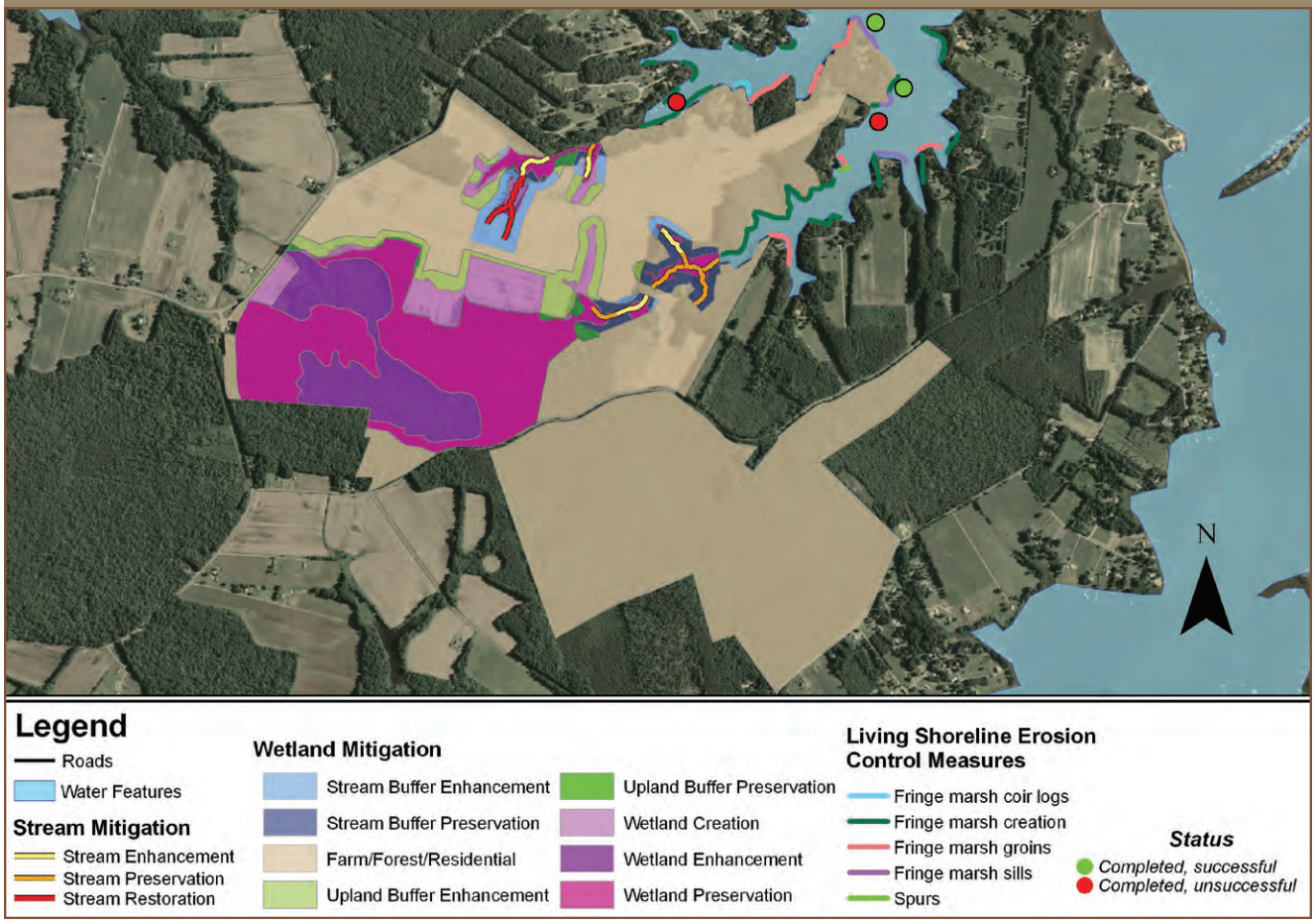
Several workshops and marsh planting events were held in 2007-08, transferring knowledge about living shorelines to local property owners, wetland board members and local elected officials. Additional workshops are planned for 2010. Future plans include further installations of different living shoreline techniques; community outreach on the currently installed living shoreline through workshops, signs, self-guided tour, and media coverage; and, monitoring the response of a wide range of organisms.

Wetlands: Approximately 213 acres have been delineated for wetland restoration, preservation and enhancement. Implementation of the wetland mitigation bank is pending approval from federal and state permitting agencies.

Forestry: 400 acres of forest land have been inventoried and a Forest Stewardship Management Plan has been written. The full implementation of the plan is awaiting wetland restoration decisions. Select forest harvest operations for revenue generation have been temporarily delayed due to the weak timber market.

Buildings: Condition assessments have been performed on all buildings and a proposed site plan has become a part of Longwood University's Campus Master Plan.

Hull Springs Farm of Longwood University Water and Wetland Features – Management Plan Map



Education: Approximately 200 Longwood University students per year participate in programs delivered at Hull Springs Farm. Five workshops on living shorelines, water conservation, rain barrels, and local history were held, reaching more than 150 local residents and officials. Dozens of volunteers participated in hands-on planting of marsh grass during three additional workshops. While a formal plan for education and outreach is not yet in place, Hull Springs Farm has hosted dozens of college courses, elementary school field days, workshops and other educational events since 1999.

KEYS TO SUCCESS

The following factors were critical to the successes achieved at Hull Springs Farm:

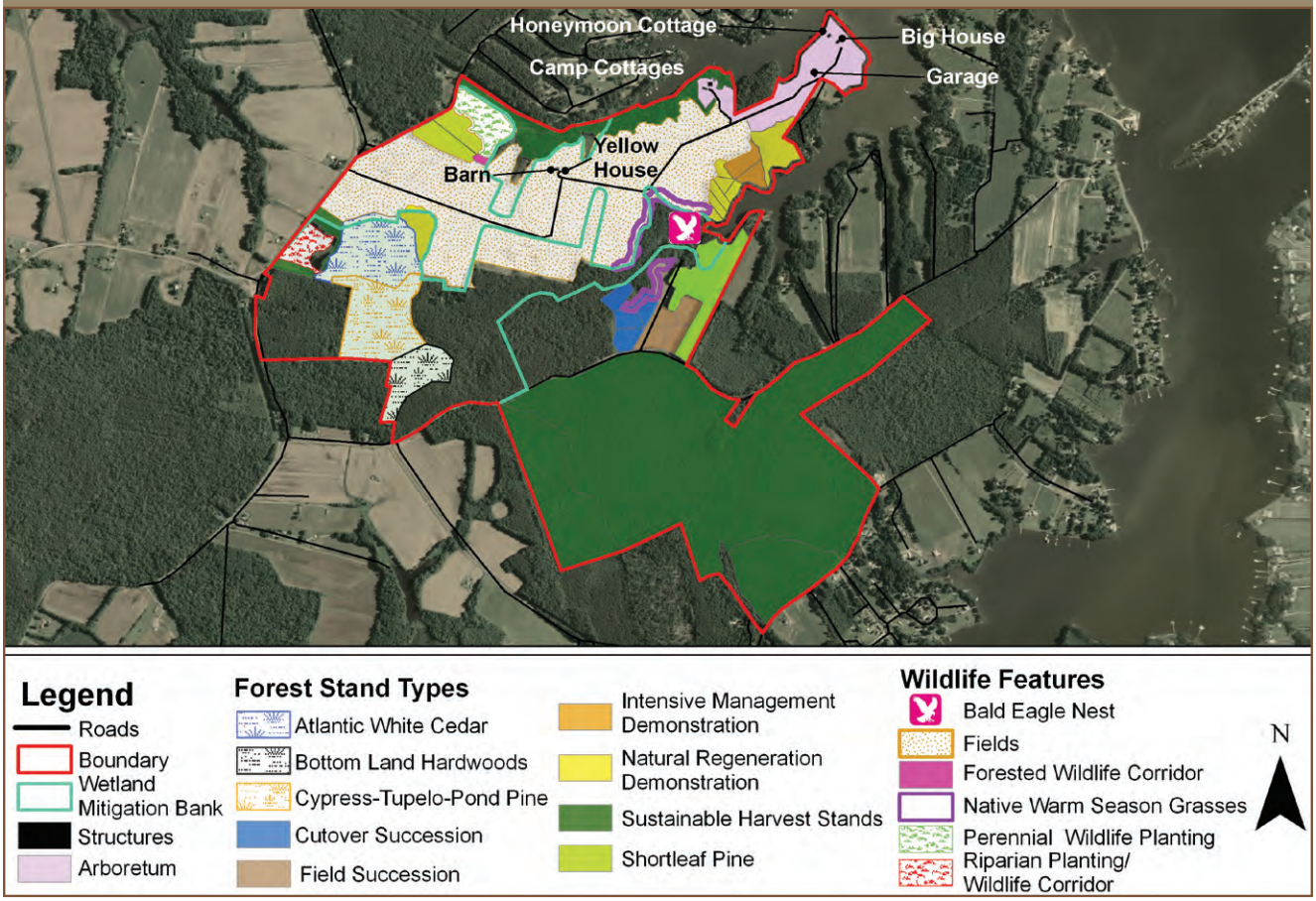
Leadership: Longwood University, the Longwood University Foundation, Inc., and the Hull Springs Foundation Board have been supportive of the mission and direction for the farm. The Longwood University Faculty Advisory Council and the Natural Resources Advisory Council contributed valuable expertise and insights that will continue to guide future development of Hull Springs Farm.

Natural Resource Assessments: While complex and time consuming to undertake, the numerous methodical natural resource inventories and assessments are essential tools for navigating the journey to an economically self-sufficient model of sustainability, conservation and land stewardship. Without these tools, the farm management team would lack the comprehensive picture of natural resource assets, problems and opportunities that they now possess.

Adaptive Management: The leadership team is willing to pursue an adaptive management approach by learning from their successes and failures, and adapting their actions in response to constantly evolving environmental and economic conditions. Their willingness to investigate and deploy innovative approaches, new techniques and original research has lead to creative problem solving and solutions.

Strong Partnerships: The management team actively pursued and nurtured partnerships with government and non-profit groups and academic institutions, enlisting their support and expertise to help

Hull Springs Farm of Longwood University Terrestrial Features – Management Plan Map



offset significant funding and staff time limitations.

Fundraising: Successful grant writing and the use of government and private sector conservation funding has lead to the support of diverse projects. Commitment to efficiency, cost effectiveness and partnerships has generated a great deal of programmatic successes in spite of financial and staff limitations.

PHOTOS AND FIGURES

All photos by Hull Springs Farm
Page 222: Figure, Burke Environmental Associates/The Conservation Fund
Page 227, 228: Figures, Burke Environmental Associates/The Conservation Fund, using Google Earth images

REFERENCES

[1]Hull Springs Farm. 2009. Shoreline Erosion Control and Habitat Research Project. Longwood University's Hull Springs Farm, Montross, VA. In, http://www.longwood.edu/hullspringsfarm/environment/shoreline.htm.

FOR MORE INFORMATION

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645 Hull Springs Farm Road, Montross, VA 22520
Phone: (804) 472-2621 | Email: hullspringsfarm@longwood.edu | www.longwood.edu/hullspringsfarm

The Hull Springs Farm web site has extensive information about its resource management plans, and contact information for groups interested in renting the buildings for educational events.

Fox Haven Organic Farm

Restoring and Regenerating the Land for Food Production and Watershed Protection

Landowners who seek to restore overworked farmlands, find alternatives to commercial fertilizer applications and enhance biodiversity on their farmlands can learn a lot from how farm operations are handled at Fox Haven Farm.

CASE STUDY SUMMARY

Fox Haven Organic Farm rests comfortably in the rolling landscape of Catoctin Valley near Jefferson, Maryland. A large stream meander bend of Catoctin Creek moves graciously through the property with the steep slopes and upper agricultural fields offering stunning distant views of the picturesque South Mountain and Catoctin Mountains.

The obvious beauty of Fox Haven Farm masks a more important need, recognized by owner Harriett Crosby, to heal the land from years of agricultural use, as well as repeated logging and erosion that affected nearby Catoctin Creek and the surrounding watershed. Crosby, her farm manager Dick Bittner, and a host of advisors, including the adept consulting team of Regenesis Group, Inc., have thoughtfully considered a long-term path to rejuvenating the eroding, spent soils of Fox Haven and providing a model for other land owners concerned about watershed restoration and sound land stewardship.

With 409 contiguous acres to manage, Crosby retained Regenesis to develop a detailed stewardship plan for the property that was remarkably comprehensive in scope and vision. An ardent protector of wildlife, Crosby has initiated a number of actions to increase biodiversity on her land. Bittner raises a variety of locally consumed crops and vegetables without the use of commercial fertilizers, herbicides, or pesticides. One-third of the soil used for crop production is set aside and renourished with "green manure" through an array of legumes for one full growing season before it returns to production.

To spread the word about the "living systems" approach used at Fox Haven, Crosby and Bittner are frequently engaged in outreach efforts—hosting demonstration tours and informative workshops on topics like beekeeping, the importance of pollinators to agriculture, and organic farming practices. The farm operates on a philosophy of "living local solutions to global problems" and ultimately hopes to create a legacy of community-minded stewards and "eco-preneurial" businesses that can earn a living off the land and continue a genuine ethic of sustainability for generations to come. The management team at Fox Haven believes in using an adaptive management approach: carefully observing what is happening on the land and directing a continuously adjusting course of action to benefit the farm and the Catoctin Creek watershed, and nurturing living ecosystems to perform at an optimal, self-regulating level in perpetuity.

RESOURCE MANAGEMENT CHALLENGE

By 1739, the land that now comprises Fox Haven was initially within the "Anchor and Hope" land grant made to Roger Touchstone, a Monocacy Valley landowner. After the land was settled, it has likely been logged three or four times—within the last 30-40 years. The only surviving large tree species are along inaccessible steep slopes or fence rows. Before Crosby acquired the eleven tracts that comprise Fox Haven, farming and grazing had occurred for generations on much of the site, including areas where slopes are in excess of 8%. This long-standing practice produced a number of resource management challenges.

Soils on the flatter, upper portions of the property that would ordinarily be more productive were compacted

Fox Haven farm looking toward South Mountain.

and severely eroded. The steeper slopes and draws found on the property have suffered years of erosion and several watercourses have deeply incised channels. Similar soil erosion and sediment transport problems on other farmlands affect nearby Catoctin and Lewis creeks and are a water quality concern throughout the watershed. Catoctin Creek quickly turns brown even after a short rain storm. Myersville, Fauquier, and Catoctin soils inhibit the practice of annual agriculture due to inherent limitations, and thin and/or spent soil profiles. All of the soils found on the site require amendment to raise their pH to a level that accommodates annual plants and they will need careful regenerative management practices for the foreseeable future to bring them back to full productivity.

A substantial amount of reforestation and habitat enhancement is needed to address soil erosion and sediment transport issues; to enhance groundwater infiltration and nutrient reduction by natural means; and to return a diversity of wildlife to the farm.

CONSERVATION VISION

In 1980, when Crosby began to acquire her Fox Haven holdings, she bought it with the three-fold vision of protecting the land from development, conserving its resources, and repairing the damage that had been inflicted over generations of misuse. As the years have passed, her vision has become increasingly comprehensive and complex—extending beyond the physical care of the land itself to the creation of a broader ethic of sustainability nurtured by a community of like-minded thinkers that aspire to more deeply understand and support the care and maintenance of interconnected, living systems. This conservation vision has been built in "layers" as she and her farm manager Dick Bittner accumulate the advice and counsel of experts from government and private sector organizations and learn through experience with their own conservation efforts. An excerpt from the Fox Haven mission statement (see sidebar) gives insight into the multi-faceted nature of conservation at the farm.

IMPLEMENTATION RESOURCES

Sound Farm Management: In 1997, Crosby retained Bittner to assume responsibility for day-to-day farm management and long-term planning for restoration and regeneration of the land. Fox Haven land management practices are loosely organized around the principles of "permaculture," which relies on a systems design approach to achieve, in part, sustainable agricultural operations with minimal amounts of energy. In line with this thinking, a conscious decision was made to reduce the

amount of equipment needed to run the farm. Bittner believes lower energy and equipment costs yield greater profits and reduce environmental impacts. Only one 50-horse-power tractor performs various maintenance tasks at Fox Haven. He has also eliminated fertilizer and herbicide costs through innovative natural weed suppression techniques and the use of legumes in rotation with production crops to replenish the soil and fix atmospheric nitrogen.

ECO-PRENEURIAL AND CONSERVATION PARTNERS

Crosby hopes to engage an increasing number of interested organizations and eco-preneurial businesses to help sustain, in perpetuity, the core permaculture values and practices envisioned for the farm.

One example of this is a cooperative agreement with a neighboring farmer who bales and then purchases all of Fox Haven's organically grown hay for his nearby organic dairy farm operation. The agreement includes the purchase of manure from his cows to nourish the fields.

Another eco-preneurial enterprise involves renting a three acre garden to Bittner for a community supported agriculture (CSA) organic produce operation. To supply water to Bittner's vegetable plot, Crosby paid $7,000 to install an irrigation and solar panel system that moves water from a nearby well; stores it in two 2,400 gallon holding tanks; and feeds it to the garden via a gravity-powered drip irrigation system.

To help offset income lost by setting aside former erosion-prone cropland for conservation practices, Crosby has gained approval of more than 100 acres of forest mitigation banking sites for the potential sale of credits needed by others to fulfill mandated forest conservation requirements. She has also loaned a portion of her land to the American Chestnut Foundation to grow a blight resistant strain of chestnut tree from the crossing and back crossing of Chinese and American chestnut species.

Technical and Financial Assistance: Cost-sharing funds from the U.S. Department of Agriculture (USDA) Conservation Reserve Enhancement Program (CREP) and Wildlife Habitat Incentives Program (WHIP) paid for the massive tree plantings at the farm (see Conservation Strategy below). Annual rent payments to the landowner for the USDA conservation programs range from $94 to $164 per acre. USDA's Natural Resource Conservation Service (NRCS) and Catoctin Soil Conservation District provided technical assistance to produce Conservation and Nutrient Management Plans that now guide farm operations. Bittner relied on Maryland Department of Agriculture staff to help explain the requirements and practices involved in becoming a state certified organic farm operation. The Maryland Department of Natural Resources' State Forest Service furnished technical support to create a Forest Stewardship Plan for the farm. Federal cost sharing funds (the lesser of $75/acre or 50% of the total cost) from the Forest Land Enhancement Program (FLEP) were also obtained through the Department of Natural Resources and used to control invasive species in established plant

Fox Haven Mission Statement

….Our intention is to do no harm as we discover how to balance the needs of the land: its water, soil, plant, and animal life, including its human community. The entire farm is organic, practicing permaculture, working with the natural flows of energy, wind, water, sun, slopes, regenerating the life force of the land, using nature to heal nature. The farm fields, tree plantings, rain gardens, composting toilets, solar pumps, drip irrigation in the organic garden, chicken tractors, mixed forests, and creeks are laboratories for learning the complex lessons of nature and discussing how to apply these learnings to our work lives.

Fox Haven serves the environmental community by offering a safe haven for meetings and solo retreats. Its meandering streams, nature trails, rolling hills, and spectacular mountain vistas provide a sanctuary for true dialogue and personal transformation.

stands at Fox Haven. Finally, Crosby retained a private consulting firm to address a broad array of issues as discussed below.

CONSERVATION STRATEGY

Studying the Land: In addition to discussing conservation strategies with government advisors, Crosby sought the assistance of the Regenesis Group, Inc., from Santa Fe, New Mexico, to assess the full array of resource opportunities and constraints affecting Fox Haven. From April of 1999 through September of 2000, Regenesis collaborated with local residents to perform an ecological and cultural inventory and assessment of Fox Haven. They produced a comprehensive report entitled Fox Haven: Voices of the Land.[1] The report also contained a summary of earlier recommendations made to the owner that divided the farm into five zones with suggested management practices. Predominant themes running through the Regenesis report are the interconnected nature of living systems; the forces of nature that affect the farm; and the ways in which future stewardship actions can contribute to regenerating the vitality of the farm in a holistic manner.

The consultants examined the historical, geological, and watershed context of the farm to convey how Fox Haven was shaped by its physical and cultural setting. A detailed analysis of the "energetic" context of the farm examined how slope, water drainage patterns, cold air movement, solar aspect, wind patterns, fire influences, noise, and light act together to continually shape the natural environment and human uses of the site. A final chapter summarized how the physiographic sectors of the farm—upper terraces, slopes, and bottom lands—could be managed in relation to future infrastructure improvements, livestock management, crop production, and resource management practices. The consultant provided examples of how landscape form and related elements interact with potential management scenarios. For example, excess biomass production and livestock fertilizer in one area of the farm can be used to regenerate depleted soils in another area. Regenesis also cited an example of how livestock shelter facilities, the movement patterns of the livestock, and their living and reproductive needs can be in complimentary alignment with landscape and resource management goals. The emphasis rests on the many interactions between living systems that must be considered and thoughtfully acted upon to achieve a better balance between ecological systems and human influences. The discussion and relationships cited by the consultant are complex and demanding of most reading audiences.

Management Zones: The principles discussed in the Fox Haven report were preceded by a more intuitive set of recommendations offered by the Regenesis Group. A brief description of some recommended management zone strategies are presented below. The zone concept could be deployed in other farm settings with goals similar to those envisioned at Fox Haven.

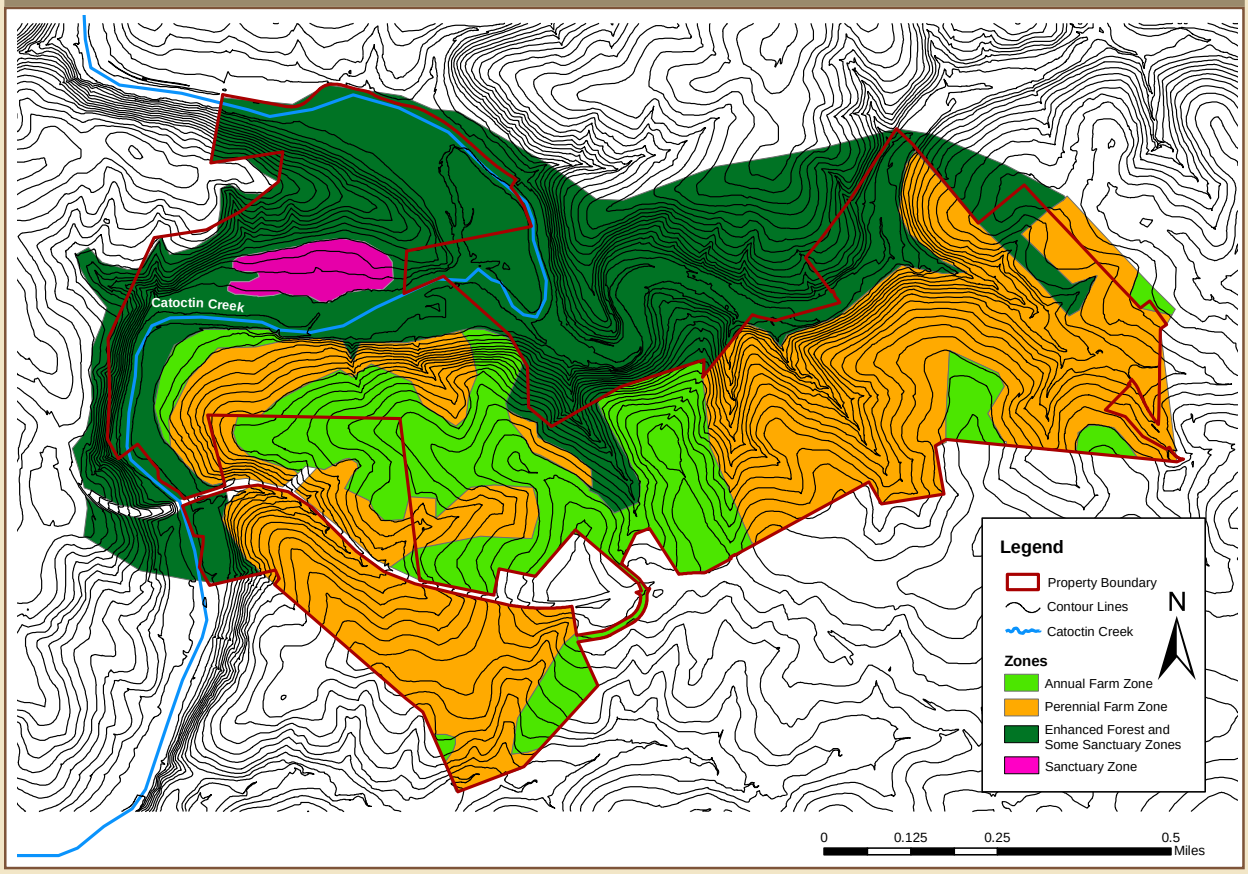
Annual Farm Zone: This zone designates an area with the most productive soils that is recommended for organic farming practices and regeneration of the soil. This entails minimal inversion of the soil layers through practices such as: keyline plowing (a cultivation pattern that directs water to and increases soil moisture absorption on hill ridges and reduces the concentration of runoff and attendant erosion problems in valleys); low tillage practices; and successional seeding in undisturbed beds. Soil-building measures included:

- Restricting export of organic material (such as baling and selling hay from an entire field) to less than 15% of a season's yield
- Generating nutrient inputs on-site and finding cost-effective ways to distribute them. Examples are turkey or chicken tractoring and using grazing animals to reincorporate organic material.

Perennial Farm Zone: This zone designates areas where virtually no tillage is acceptable due to potentially high erosion and poor soil profiles. Sample recommendations include:

Red fox, a common sight at Fox Haven farm.

Fox Haven Farm Generalized Farm Zones



- Create a multistory, stacked perennial farm—a food forest. Use higher-grade cultivars and more costly plants in this area.
- Group orchard and nursery on the near reaches of this zone, closest to the farm center.
- Create a successional wave across the landscape: rotate through grasses and wildflowers (becoming pasture), then nut and berry shrubs, then orchard, then return to grasses and wildflowers.
- A slope ranging from 8 to 12 percent may be suited for perennial pasture.

Enhanced Forest Zone: This zone designates development-free areas for an enhanced heritage hardwood forest complex that stabilizes the landscape, adds diversity, and has the potential for providing a wild gene pool for other parts of the watershed. Some recommendations are:

- Possible reintroduction of the keystone chestnut, when blight-resistant chestnuts are fully developed and available
- The planting of cultivars that have enhanced value, disease resistance, and commercial qualities
- The extension of existing vegetation and tree plantings to create guilds of high-value heritage hardwood nut and timber trees, interplanted with guilds of nut and berry shrubs
- The selective harvest of valuable timber, once a solid canopy has been achieved, to create openings and glades in the canopy. Begin the cycle again in the clearings, creating a multi-age forest complex.
- Eventual succession into Perennial Farm Zone, if desired.

Sanctuary Zone: This zone designates the most remote and least disturbed area on the property, with the best existing wildlife habitat that should be minimally disturbed. An abbreviated list of recommendations includes:

- Perhaps once in every 10 years create glades by sustainably harvesting timber in small areas. Harvest intensively to simulate the effects of natural catastrophic events such as fire.
- Inoculate with fungi and introduce a broader diversity of berries to edges.
- Transition the summer grasses meadow to a more diverse native prairie system.

RESULTS

With a well considered set of conservation strategies in hand, restoration efforts on Fox Haven Farm moved into high gear starting in the year 2000. Approximately 65,000 trees were planted under the Conservation Reserve Enhancement Program (CREP) and the Wildlife Habitat Incentives Program (WHIP). Several species of trees were selected, including red oak, swamp oak, willow oak, white oak, pin oak, walnut, sycamore, locust, dogwood, red bud, red cedar, pitch pin and Virginia spruce. In addition to the tree plantings, a significant amount of acreage was devoted to warm and cool season grasses for erosion control and wildlife habitat enhancement. Also, Fox Haven Farm was expanded with the purchase of neighboring Spring Manor Farm (149 acres), bringing the total holdings to approximately 550 acres. New CREP plantings were quickly established on this property early in 2009, adding a remarkable 14,000 trees and shrubs and more than five acres of warm and cool season grasses.

The table below summarizes the government cost share practices installed at Fox Haven (not including Spring Manor Farm).

Beyond the impressive installation of numerous conservation practices, Bittner makes it a point to emphasize the benefits of his "green manure" program. Bittner explains that the legumes he uses—such as hairy vetch, soy beans, crimson clover, and buckwheat—replenish the soil on a third of the crop production areas each year and provide enough nutrients to produce abundant, healthy crops. Bittner has also worked out his own methods to control weeds without using herbicides. Through a combination of mowing, and planting orchard grass and other clover mixtures, he naturally discourages weeds and invasive plants from crowding out young tree plantings. Bittner also conducts experiments in plots around the farm to observe how natural succession is proceeding in selected areas and how invasive species control techniques are or are not working. Crosby has installed a number of blue bird boxes around the property, and maintains a small chicken house to ensure a supply of organic eggs for her neighbors and friends.

Based on the extensive planning efforts and years of experience managing Fox Haven, Crosby and Bittner have established a basic set of farming practices they expect to live by until they learn from their mistakes better ways of doing things. The practices could benefit any farm owner looking to improve water quality, soil productivity, and watershed health. The practices include:

- Use "crop fencing" in preference to wire as a means of pest control. Feed the deer before they find the "money crops"!
- Create buffer strips around property lines to absorb genetic and pesticide drift from neighboring fields.
- Use no-till or low-till practices where practical and possible. Keeping the soil covered with plants or mulch helps prevent compaction from wind and rain.
- Grow cover crops (preferably legumes) on one-third of all cropland at all times. Use crop rotation to establish a "two-year rebuild and four-year crop" cycle while providing beneficial weed control.
- Minimize practices that suffocate soil. Discarded material such as plastics and lumber, as well as unnecessary off-road vehicular use will leave marks of suffocation followed by emergence of unwanted vegetation like thistle, Johnson grass and burdock.
- Minimize the time that the earth is exposed without a beneficial cover crop. Unattended exposed soils create unwanted vegetation.
- Maximize the practice of planting on contour elevations or "key lines." Erosion control, water retention, and ease of maintenance are natural benefits.
- Use companion planting practices to enhance insect and pest control.

Cost-Share Conservation Practices Installed at Fox Haven Organic Farm

Practice	Fund Source	Acreage
Trees and Shrubs	Conservation Reserve Enhancement Program	118
Warm Season Grasses	Conservation Reserve Enhancement Program	9.5
Cool Season Grasses	Conservation Reserve Enhancement Program	9.1
Trees and Shrubs	Wildlife Habitat Incentives Program	20.3
Warm Season Grasses	Wildlife Habitat Incentives Program	9.8
Invasive Species Control	Forest Land Enhancement Program	150
		Total Acreage Affected: 306.9

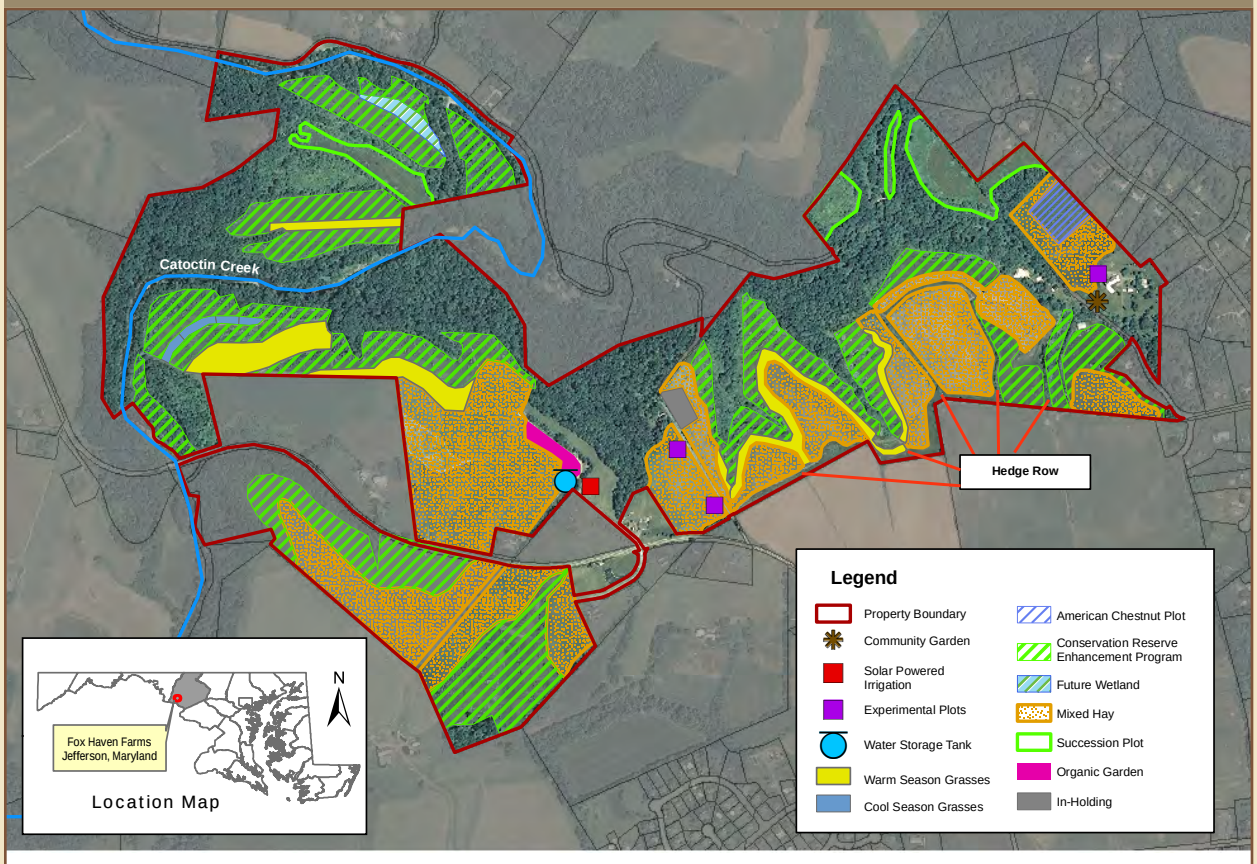
- Control undesired seed-producing plants prior to their maturity by mowing. Use desirable ground covers and frequent mowing to avoid and eradicate.
- Encourage diversity of plants where practical and possible. Avoid patterns of uni-cropping.
- Use native plants whenever possible to support native wildlife, including pollinators.
- Learn to recognize and control these invasive plants: Ailanthus (Tree of Heaven), Johnson grass, Canadian thistle, Japanese hops, and multi-floral rose.
- Conduct forest assessments on a periodic basis and perform soils tests on two-year cycles.
- Maintain an ongoing nutrient management program that includes soils tests, water quality tests, sediment control assessments, and forest assessments.
- Minimize practice of taking bio-mass away from farm where practical. Hay sales conflict with this practice, but spreading manure from the cows on the fields offsets.
- Limit vehicular traffic to designated areas. "Walk and learn" will become standard practice.
- Choose seeds and plants that conform to the Maryland Department of Agriculture Organic Certification Department's standards.
- Avoid any use of chemicals or synthesized fertilizers unless they conform to Organic Certification Standards. Initiate a trial plot and incorporate "green manure" (legume cover crops) to achieve replacement for all synthesized fertilizers.

KEYS TO SUCCESS

Crosby and Bittner offered the following advice for replicating their success at Fox Haven:

- Develop a deep understanding of the land and its natural occupants, potential opportunities, and inherent limitations of your property, and strive to become a land steward with a sustainable farm operation that benefits you and the broader community.

Fox Haven Farm Conservation Plan



Source: Dick Bittner

LEFT: ***CREP forest planting at Fox Haven Farm.***
RIGHT: ***Cotoctin Creek.***

- Formulate a comprehensive resource management and farm plan that considers near- and long-term planning horizons. Use an adaptive management approach to continually observe and adjust your operations to improve performance.
- Make use of government and private sector expertise and funding for conservation practices.
- Be aware of the amount of energy and resources consumed to manage the farm and do your best to apply the most appropriate technology or low-tech solutions to achieve an economically and environmentally sustainable farm.

PHOTOS AND FIGURES

Page 229-230: Photos, David Burke
Page 232: Photo, Harriett Crosby
Page 233: Figure, Burke Environmental Associates/The Conservation Fund, adapted from Regenesis Group, Inc., 2003
Page 235: Figure, Burke Environmental Associates/The Conservation Fund, using NAIP image
Page 236: Photo (left), Dick Bittner; photo (right), David Burke

REFERENCES

[1]Regenesis Group, Inc. 2003. Fox Haven: Voices of the Land. Regenesis Group, Inc., Santa Fe, NM. Excerpts available online at: http://www.regenesisgroup.com/pdf/Innem.pdf.

FOR MORE INFORMATION

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USDA Conservation Programs

Improving Water Quality and Wildlife Habitat on Maryland's Eastern Shore

Duvall Farm serves as a model for small farm operators and large-lot residential estate owners who can use the U.S. Department of Agriculture's (USDA) conservation programs to create a more diversified model of land management that improves local water quality and results in aesthetically pleasing landscapes supportive of Eastern Shore waterfowl populations and wildlife.

The 490-acre farm sits amidst a picturesque setting on Maryland's Eastern Shore, a short distance south of Easton and adjacent the headwaters of Trippe Creek off the Tred Avon River. At Duvall Farm, owners Chip and Sarah Akridge, their wildlife/farm manager Clay Robinson, and conservation construction contractor Daniel Kramer of Sweetbay Watershed Conservation have literally sculpted the landscape to create a sanctuary for wildlife alongside of income-producing farmland.

From the outset, the plans for Duvall Farm incorporated management practices that would enhance water quality and limit nutrient and sediment pollution from entering Trippe Creek. The farm has become a show place for on-the-ground implementation of the USDA's Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), and the Wildlife Habitat Incentives Program (WHIP).

Beginning in early 2004, the Akridges worked with the Natural Resources Conservation Service (NRCS) and other cooperating agencies to develop design plans and conservation contracts for their property. In 2005, they completed installation of wetlands, vegetative buffer systems, shallow water areas, and other conservation practices in accordance with the plans.

In the past, the Akridges and their support team implemented conservation practices that benefited water quality and wildlife on several other properties that they own. Their methods showed steady improvement as the installations matured and the team learned from their positive attributes and shortcomings. In consultation with experts from both government and private organizations, the owners were now in a position to fine-tune their efforts to produce the best possible results. Both the Akridges and their farm manager hope that the learning curve they have experienced will allow others to "short-cut" through a web of potential pitfalls and get things right the first time.

RESOURCE MANAGEMENT CHALLENGE

Duvall Farm started out with virtually no habitat for wildlife—particularly waterfowl and upland bird habitat or the necessary aquatic regimes to host fish, turtles, and amphibians. Measures to protect water quality were limited or altogether lacking, and existing farm runoff was not processed through natural buffer systems or other means to allow groundwater infiltration. Extensive grading was required to create the conditions needed to retain surface water runoff and to avoid both the erosion and colonization of the newly created areas by invasive or undesirable plant species. All of this had to be accomplished within USDA guidelines that narrowed, to some extent, the range of options available to the owners for other farm and recreational operations.

CONSERVATION VISION

The Akridges' vision for Duvall Farm is to create and restore wildlife habitat and improve water quality, while maintaining productive agricultural lands. Chip Akridge acknowledges the tremendous help available to achieve his vision through the USDA's CRP and CREP programs noting that "... with careful design, these programs can recreate the natural

The scenic 17-acre lake at the core of Duvall Farm. The lake hosts several species of waterfowl that move freely between this water body and nearby impoundments.

habitat which was historically present in the area which will:

- Provide suitable habitat for the re-establishment and growth of vanished and existing wildlife species, including song birds, game birds, waterfowl, and upland game;
- Improve the quality of runoff into the Chesapeake Bay by minimizing the use of fertilizers, pesticides, and herbicides and by reducing erosion; and
- Replace suburban-type residential development sprawl with open space for the community at large to view and enjoy."

Any visitor to Duvall Farm quickly surrenders to the aesthetic appeal and soft edges of the property that teem with wildlife. In part, the successful conservation story at Duvall Farm is due to a larger regional vision for the area.

Immediately north of Duvall Farm is a conservation subdivision called Cooke's Hope at Llandaff (also featured in this publication). Significant wildlife habitat creation projects were instituted at Cooke's Hope/Llandaff not long after the improvements at Duvall Farm. The management group at Cooke's Hope/Llandaff employed the Akridge team to design the wildlife habitat areas to closely resemble those at Duvall and expand the conservation improvements on the adjacent properties.

In conjunction with the habitat/water quality practices developed at Duvall Farm, the synergies of these adjacent parcels were deliberately intended to reinforce each other and introduce a growing regional matrix of private wildlife habitat that could be compared in scale and effectiveness to a publicly owned wildlife refuge.

IMPLEMENTATION RESOURCES

The CRP, CREP, and WHIP were the primary financial resources used to pay for the practices installed at Duvall Farm. CREP was the best fit for the owners—with cost-share amounts ranging from 75 to 90% of construction costs and annual rent payments that were comparable to farm rental rates. In addition, the technical support provided by the NRCS, Maryland Department of Natural Resources, and the U.S. Fish and Wildlife Service was very valuable and a requisite to maintaining compliance with the various programs. Without the financing provided for the conservation

The Conservation Reserve Program and Conservation Reserve Enhancement Program

The purpose of the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP) is to provide technical and financial assistance to eligible landowners to address soil, water and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The CRP encourages landowners to convert highly erodible cropland and other environmentally sensitive areas to permanent cover, such as introduced native grasses, trees, filter strips, riparian forest buffers, wetlands and shallow water habitats. In Maryland, CREP offers additional incentives to encourage landowners to implement practices that will help reduce sediment and nutrients in the Chesapeake Bay and will improve wildlife habitat.

practices, which affected nearly 35% of the property, the projects would not have been feasible.

Wetland creation and associated grading expenses represented a significant portion of the costs. Wetland construction was typically billed according to the number of yards of soil moved and varied according to fuel costs. Plant materials were relatively inexpensive because most were established from bare root seedlings or seed. Labor charges were modest due to the low level of technical expertise needed to accomplish the planting. Although volunteers were not involved with the initial plantings, the owners have subsequently used Chesapeake Bay Foundation volunteers to plant in new areas and replace original materials that failed after installation. Tree plantings were done by the Maryland State Forest Service; private contractors installed tree tubes for deer protection and drilled warm season grasses and wild flower seeds in the herbaceous portion of the buffers. The conservation treatments involved work on a total of 171 acres.

CONSERVATION STRATEGY

The Akridges and their farm manager were concerned with the accomplishment of two principal objectives:

- Controlling sediment and nutrient runoff
- Maximizing their target wildlife species populations

When the project was completed, they wanted to see large numbers of waterfowl and upland birds (both game and non-game species) using the property. The principal mechanism to achieving both objectives was to create new wetlands and restore former wetlands. The owners were well aware of the functional role wetlands could perform in enhancing water quality by capturing sediment and nutrient-laden runoff from their agricultural fields. They also wanted to create a multi-tiered system of buffers with zones of grass, shrubs and/or trees to ensure better filtration of runoff around fields and riparian areas. The wetlands and temporarily flooded fields created ample habitat for waterfowl, and the buffer systems produced the added upland bird habitat they sought.

Wetland Creation Specifics: The wetland creation and restoration work began with extensive soil sampling. The locations selected for artificial wetlands must have soils capable of holding water for at least part of the year. Once the design team identified suitable locations, they configured the wetlands to best meet their goals of attracting waterfowl for viewing and hunting. To take advantage of USDA cost-share programs and the expertise offered by the involved agencies, the owners built their wetlands to comply with USDA criteria. The bulk of their wetland acreage is enrolled in CREP. CREP requires that a significant portion of the wetland be allowed to function within the ebb and flow of natural hydrological cycles of precipitation and shallow groundwater conditions without altering water levels. These areas provide local ducks and geese with nesting habitat and also furnish habitat for fish, turtles, and amphibians year around.

Wintering, migratory waterfowl benefit most from the food sources produced from annual plants that are flooded in the winter. In order to achieve this scenario, large portions of the impoundments are drained during early spring to promote the growth of seed-bearing annuals such as millets, sedges, and grasses. These areas are re-flooded in the early fall, either artificially or with captured rainfall, to make the food available. The technique creates and maintains permanent and seasonal wetlands in the same location. The seasonal wetlands result from a constructed berm around a portion of the field where runoff is impounded and the water level is raised or lowered through a water control structure. The permanent wetlands are created by excavating deeper areas within the same compound.

Buffer Specifics: All buffers were designed to filter sediment and nutrient runoff, as well as provide upland bird habitat. Generous buffer widths ranging from 120 to 150 feet were created by removing a portion of the existing agricultural field from production and planting it with trees, shrubs, and grasses. All agricultural fields and riparian zones now host buffers initiated through CREP or the CRP. The Quail Buffer (called Conservation Practice #33 or “CP-33” for short) is in the CRP. Robinson noted that CP-33 is the only NRCS practice that can be used to buffer a field strictly for wildlife enhancement. All other practices buffer runoff adjacent to a water feature. Most areas made use of the step-down method, which breaks the buffer into two or three

A created Shallow Water area at Duvall Farm — NRCS conservation practice CP-9.

zones. Trees were planted in the outside zone, nearest existing woods; shrubs were planted in the middle zone; and grasses were planted in the inside zone nearest the agriculture. This triple zone of filtration does a better job of trapping sediment and removing surface and subsurface nutrients. It also establishes a soft edge that is beneficial to wildlife and aesthetically appealing. In some areas where woods are not present or desired, only two zones were used—shrubs and grasses.

Installation and Administrative Issues: Overall the installation of conservation practices went very smoothly due to several factors. First, the owners retained a knowledgeable and experienced contractor, Dan Kramer with Sweetbay Watershed Conservation, who was well versed in the construction and design requirements of CREP. Second, the owners and farm manager had the ability to incorporate new ideas into the project while it was being designed, such as the addition of islands and peninsulas in the wetlands.

One tradeoff involved the use of one of the wetland berms as an access road to a structure on the property. CREP does not allow for this type of activity, so a compromise was reached with federal administrators. The portion of the berm that is used as a road was not enrolled in CREP, but the wetland created by the impounded water is in the program. The paper trail requirements of the USDA government cost share programs were time-consuming, but resulted in a significant construction cost savings along with an annual rent payment for those portions of the farm that were converted from agriculture to install the conservation practices.

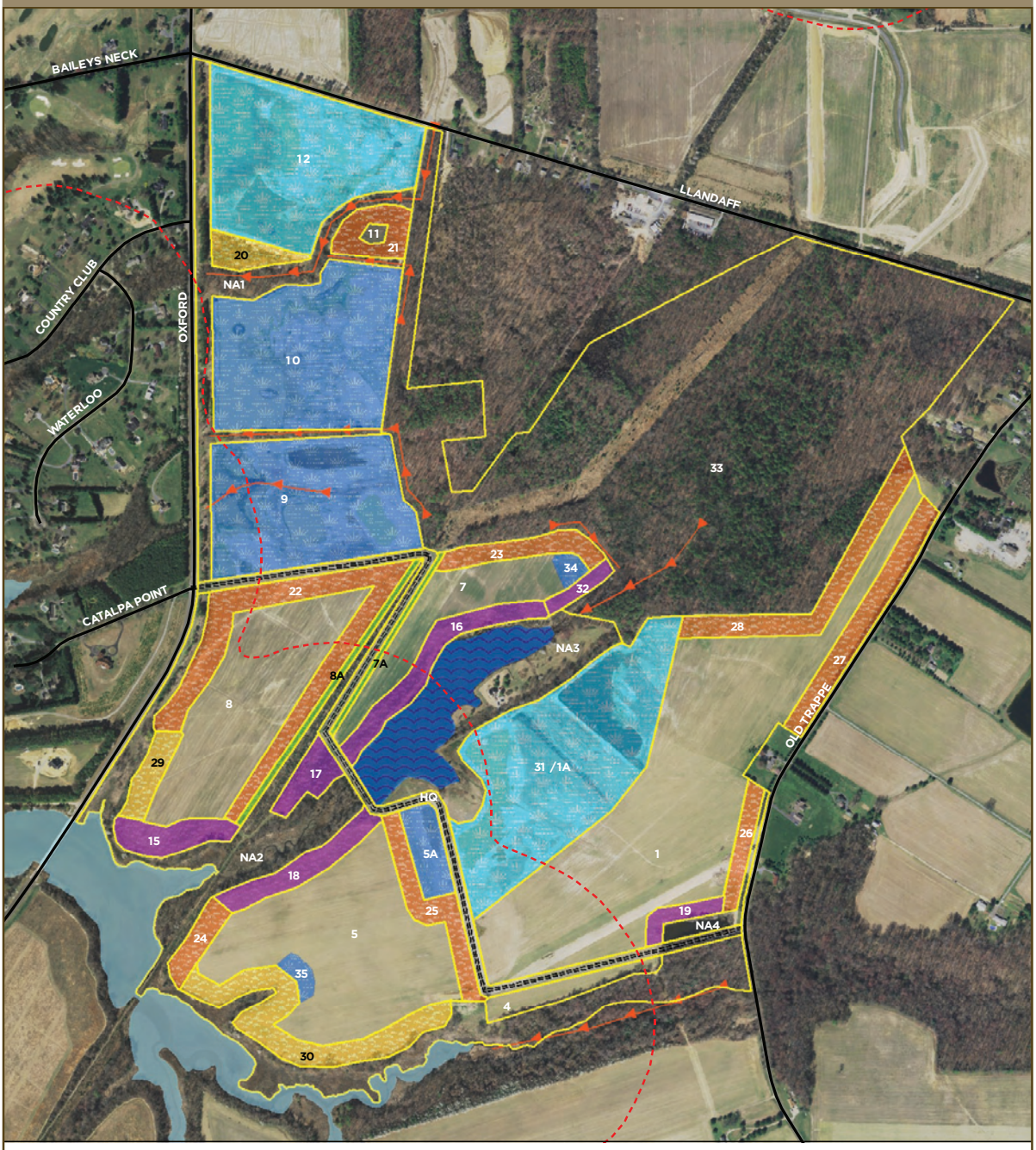
RESULTS

Water Quality: Water quality improvements associated with the buffered runoff were not measured scientifically because the owners lacked a pre-construction baseline data set and because other lands drained into Trippe Creek. However, the owners report a noticeable improvement in water clarity and sediment runoff from the property, which is evident after every rainstorm.

Wildlife: Wildlife observations were documented by the owner and increases have been tremendous. In the wetlands, duck production had gone from almost nothing, because there was no habitat, to 445 wood ducks and 249 mallards in 2008. The statistics were compiled from observations made in artificial nesting structures erected in the constructed wetlands. Beyond these individuals, there was additional production by ducks using the natural cover and vegetation.

In the winter, migrating ducks and geese have been attracted to the new wetlands in large numbers. By flooding different cells at different times in the fall and winter, and therefore

Conservation Plan Map



LEGEND

- Property / Field Boundary
- Quail Habitat Buffer
- Riparian Forest Buffer
- Shallow Water Area
- Tree / Shrub Establishment
- Warm Season Grass Buffer
- Wetland Creation
- Pond
- Farm Lane
- Drainage
- Talbot County Roads
- Trippe Creek
- Critical Area

Tract: 2236
Farm: 221 0
Plan: 831 47

Scale: 1 " = 660'

660 0 660 1,320 Feet

making new food sources available, the property supports waterfowl for long periods of time. "It's gratifying to see the large flocks of ducks and geese using the wetlands that were just corn fields three years ago" says Robinson.

A total of 146 bluebird boxes were installed in the buffers around the fields and the manager has observed huge increases in bluebirds, swallows, and grassland species of songbirds. A May 2008 survey showed 471 fledglings.

KEYS TO SUCCESS

Farm/wildlife manager Clay Robinson offered the following recommendations for replicating the success of Duvall Farm conservation initiatives:

- Have a clear plan with identified goals on the front end.
- Use CREP to receive cost-share funds.
- Make use of government and private organizations for their technical expertise.
- Recognize the maintenance needs, and commit adequate funds and equipment to do the job properly.
- Conduct annual surveys to monitor the condition of the installed practices and the results they are or aren't achieving.
- Keep an open mind about your own observations and the observations and suggestions of others.
- Be willing to add small improvements to the project, as long as they don't conflict with the program regulations.
- Take time to enjoy what has been created and be satisfied with your results.

PHOTOS AND FIGURES

All photos by David Burke
Figure by Shawn Smith, Talbot Soil Conservation District

LEFT: *A forested riparian buffer planting at Duvall Farm – NRCS conservation practice CP-22.*
RIGHT: *A period reproduction building adjacent to Duvall Farm pond.*

FOR MORE INFORMATION

Project Contact:
USDA Service Center
www.sc.egov.usda.gov/ContactUS.html
Contact local office for information on eligibility requirements, practices, and payments

Using Engineered Wetlands to Enhance Water Quality

A Natural Treatment System at the Philip Morris USA Property Along Virginia's James River

Philip Morris USA's new natural treatment system shows how private industries and municipalities can use man-made wetlands to further reduce harmful pollutants in processed wastewater before they enter the Chesapeake Bay or its tributaries.

CASE STUDY SUMMARY

Philip Morris USA (PM USA) has created 48 acres of engineered wetlands on their Park 500 property in Chester, Virginia, adjacent to the James River, which enhances the traditional on-site wastewater treatment process at this tobacco processing facility. The engineered wetlands assimilate pollutants by physical and biological processes aided by gravity. The benefits of this system include: improved water quality, reduced mass and hydraulic loads, and the creation of significant wildlife habitat.

Private corporate natural treatment systems like this one are uncommon in the Chesapeake region. The Chester plant directly withdraws water from the James River and is permitted through the Virginia Pollutant Discharge Elimination System (VPDES). While there is no flow limit or secondary treatment technology standard required in the permit, PM USA estimates a typical river withdrawal rate of 2.05 million gallons per day (mgd) and a wastewater discharge of 1.53 mgd. This water is used in the manufacturing process and is then treated for various substances present in the wastewater, such as nitrogen, phosphorus, and suspended solids. Over several months of the summer, excessive nitrogen and phosphorus have created a 100 mile-plus "dead zone" in the main stem of Chesapeake Bay that lacks sufficient oxygen to support aquatic life. In nutrient enriched shallow waters, and poorly flushed areas found in tributary systems like the James, algal blooms frequently occur during the summer. When the algae die off, low dissolved oxygen conditions are created that can reduce suitable habitat and kill or stress mobile species such as fish and crabs, as well as stationary bottom life like clams and worms. Reducing nitrogen and phosphorous loads to the James is essential to its restoration and removal from Virginia's impaired waters list.

In 2002, PM USA formed a "zero discharge team," to evaluate and institute changes to their wastewater treatment plant and improve environmental performance. The team evaluated a range of technologies in hopes of finding a way to reduce effluent flow by reusing or recycling the facility's wastewater. The team identified a number of options ranging from reverse osmosis to land application. Ultimately, PM USA decided to create a natural treatment system modeled after an existing one in Clayton County, Georgia. While this was not a zero discharge design, the company hoped it would significantly reduce pollutants in the wastewater.

In 2006, PM USA hired CH2M HILL, a leading construction and engineering firm, to design and build a natural treatment system based on engineered wetlands. The design employs shallow and deep water pools, with native plants and natural filtering techniques that absorb pollutants. The system was designed to further reduce total nitrogen discharge by 13% and phosphorous discharge by 34%. Initial results actually exceed these figures, but this preliminary data represents a period of rapid plant growth and pollutant uptake levels that are not likely to be sus-

Aerial view of the natural treatment system at the Philip Morris USA property known as Park 500, located on the James River in Chester, Virginia.

tained over time. The wetlands have also created new habitat for several wildlife species.

The entire system cost $7.175 million and was commissioned in June 2008. In 2009, the project was recognized by the Virginia Environmental Excellence Program for a pollution prevention approach that goes above and beyond the legal requirements.

RESOURCE MANAGEMENT CHALLENGE

The James River is one of America's most historic rivers, often referred to as America's Founding River, and lays claim to the first permanent English settlement at Jamestown, established more than 400 years ago. Development, pollution, and overfishing have now damaged the river ecosystem, particularly within the last 30 years.

Recent efforts have begun to reverse the river's decline and the state has laid out a plan to restore the river to full health—including the reduction of nitrogen and phosphorous pollution. However, pollution from across the watershed continues to have adverse impacts on the river.[1] In 2008, the James River Association gave the river an overall score of 52 out of 100. An "A" grade, or fully restored condition, would require a score from 80 to 100 points. Populations of native fish and shellfish, such as trout, shad, and oysters, remain far below historic levels. Moreover, at the current pace of development, Virginia will develop as much land in the next 40 years as it did in its first 400 years,[2] which will result in significantly more pollution entering the river.

The largest amount of pollution comes from runoff originating on farms and developed areas, which carries a toxic mix of bacteria, sediment, heavy metals, nitrogen, phosphorus, and pesticides.[3] Some of these same pollutants also come from sewage treatment plants and industrial discharges, such as from PM USA's Chester facility. All these pollutants combine to cause ecological and water quality problems for the James. The river's impaired condition and future development pressures require

government, non-profits, corporations, and private citizens to each do their part to restore the river.

The Chester plant property is adjacent to Bermuda Hundred, a historic community which was established in 1613, and served as the early port of Richmond. PM USA's Chester facility opened in 1975 to reuse tobacco materials. Essentially a recycling facility, the plant processes small pieces of tobacco, such as stems and dust, from other facilities into a sheet product called reconstituted tobacco. This paper-like tobacco is shipped to other Philip Morris plants, shredded, and blended with virgin tobacco to make cigarettes. This process typically requires the use of up to 2.05 million gallons of water a day from the James River. The water is used in the reconstituted tobacco manufacturing process, then treated at an on-site wastewater treatment facility, and released back into the river.

The Chester facility is a direct discharger of wastewater. Therefore, the Virginia Department of Environmental Quality requires PM USA to obtain a discharge permit. The facility must demonstrate compliance with permit limits via monthly discharge monitoring reports. The plant uses conventional wastewater treatment technology (physical settling, and activated sludge and chemical treatment processes) to ensure compliance with all permit requirements before discharging treated wastewater to the river.

CONSERVATION VISION

PM USA managers had previously committed to reducing the environmental impact of their business and to promoting sustainability of natural resources. Recognizing the regional struggle to restore the Chesapeake Bay and its tributaries, PM USA specifically pursued avenues to reduce its total nitrogen and phosphorous loadings to the James River. Between 2001 and 2006, operational changes and incremental upgrades to their existing wastewater treatment facility reduced nitrogen by 46%, but PM USA leadership was determined to do better in order to meet shareholder and community expectations. They also hoped to address concerns raised by some stakeholders, like Chesapeake Bay Foundation, who sued the state in connection with the reissuance of the facility's discharge permit in 2004.

PM USA began formulating their conservation vision through the creation of a "zero discharge team," which worked to improve the environmental performance of their wastewater treatment plant. In 2002, the team evaluated several options that would result in fully recycling the discharge water and those that would reduce pollutants. They considered reverse osmosis, land application (silviculture and spray irrigation), municipal treatment, and reuse of boiler blow-down in cooling towers. The estimated costs for installing these options ran from $28 million to $500,000, with widely varying maintenance and operations costs. Ultimately, the company chose to pursue the natural treatment system.

PM USA's environmental and operational staff was already aware of the potential for wetland ecosystems to improve water quality. Natural wetlands have been used for wastewater collection for more than 100 years. Wetlands also have a high rate of biological activity and can transform harmful pollutants in wastewater to harmless byproducts and essential nutrients.[4]

Man-made or engineered wetlands are constructed ecosystems that also improve water quality, flood storage, and landscapes for active and passive recreation. The "zero discharge team" found that the ability of engineered wetland systems to treat municipal, industrial, and agricultural waste has been recognized for 30 years and studied extensively in North Carolina,[5] Michigan,[6] Florida,[7] New York,[8] and in many places in Europe. Such systems are now an accepted pollution control technology[9,10] and can be effective at decreasing the concentrations of nutrients, metals, pathogens, suspended solids, biological oxygen demand, and trace organics. In addition, natural treatment systems typically require fewer personnel, consume less energy, and have ancillary benefits. There are numerous demonstration projects across North America and Europe that have proved the concept.

Having selected the natural treatment system as the best solution, PM USA contracted with CH2M HILL, a noted consulting firm with expertise in this treatment practice. CH2M HILL was tasked with conducting a feasibility study that provided three conceptual alternatives for the wetland design: maximum treatment potential; maximum aesthetic benefits; and combined habitat, aesthetics, and treatment. PM USA's primary objective was water quality treatment, so they chose the option with maximum treatment potential—a simpler design that maintained a high percentage of marsh over open water zones.[11]

IMPLEMENTATION RESOURCES

PM USA paid for the entire cost of developing their conservation strategy using a combination of in-house resources and a team of consultants; they also paid for constructing and operating the natural treatment system. The total construction cost was approximately $7.175 million, which included the construction of the wetlands, transmission pipelines, pump station, and outfall structure. This cost is approximately $150,000

per wetland acre or $2.40 per gallon of installed capacity. PM USA staff indicated that the figures shown in the tables here reflect the higher end of the cost continuum for a natural treatment system. Thus, others contemplating a similar project should not use these figures to benchmark their specific needs and situation.

PM USA had to obtain several permits before starting construction, including a land disturbance permit from the county and state. Installation began in August of 2007, and the system was first flooded with water in March of 2008. All wetland cells were planted by June of 2008.

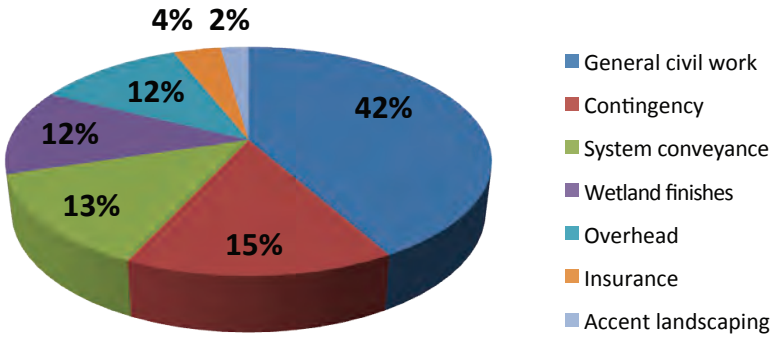
Principal costs for operating and maintaining the wetland are to power the pump, monitor the system, and maintain the levees. A large portion of the maintenance revolves around assuring that flows are consistent and that hydraulic control structures are operating at correct depth. Additional management efforts include consistent vegetation maintenance, periodic troubleshooting, and mosquito monitoring and control. The estimated cost for annual operation and maintenance is $139,950.

There were two primary constraints to implementation:[12]

- **Regulatory limitations:** Construction of the wetlands triggered the need for state and local permits, like those for erosion and sediment control. Operation of the wetlands also triggered a permitting analysis to determine future potential limits and regulatory requirements. The Virginia Department of Environmental Quality approved the project as experimental in nature and, as a result, did not incorporate it into the VPDES permit. In addition, treatment wetlands are generally considered a component of a wastewater treatment system, not jurisdictional wetlands, and therefore are not regulated by the wetland provisions of the Clean Water Act.

- **Land area requirements:** Engineered wetland processes are land-intensive because the wetlands are shallow and the water is expected to remain in the system for days or weeks at a time. According to CH2M HILL, a treatment wetland receiving 1 mgd with a design hydrologic residence time of 10 days and a design depth of 1.5 feet will require 20 acres. Because the Chester facility sits on several hundred acres of property, PM USA was able to meet this requirement.

Natural Treatment System Costs (excluding design) Total = $7,175,000



The expertise of CH2M HILL was a critical resource for this project. The firm was intimately familiar with the design and construction issues of primary importance for natural treatment systems, including influent flows and loads to the wetland; wetland performance and the area and volume required to achieve treatment goals; and the physical and biological wetland system components needed to achieve pollutant processing rates. CH2M HILL also brought with them critical expertise in conventional civil engineering, mechanical design for measurement devices, and architectural/landscape design.[13]

Approximate Estimated Annual Operation and Maintenance Costs for Natural Treatment System

Item Description	Unit	Cost	Quantity	Item Cost
Routine maintenance of pumps, inlets, weirs, pipelines	each	$210	110	$23,100
Vegetation Management	acre	$575	ND	as needed
Mosquito monitoring/control	grtly	$2,000	ND	as needed
Weekly monitoring	each	NA	364	NA
Sediment metals (annual)	each	$300	12	$3,600
Annual reporting	annual	$50,000	1	$50,000
Total operations, maintenance, and monitoring costs				$139,950

CONSERVATION STRATEGY

Initial Environmental Scan

The PM USA team realized that their vision for improving water quality would also disturb a substantial portion of the site. To ensure that construction activities would result in minimal harm to historical, cultural, and environmental resources, PM USA officials consulted with state officials and private consultants to understand the full scope of potential resource management issues.

- **Cultural Resource Inventory:** Given the rich history of the Bermuda Hundred community, PM USA retained a cultural resources consulting firm, Gray and Pape, Inc. The firm assessed the current state of knowledge regarding previous archaeological and historical research conducted within the project area; they conducted field reconnaissance to determine the condition and integrity of the identified cultural resources and to evaluate the potential for those that were unrecorded. A full technical report outlined protocols for the treatment of unanticipated archaeological discoveries and the documentation of cemeteries or human remains. An archaeological sensitivity model divided the project area into four zones that represented the relative potential for presence of cultural resources. High and moderate zones signaled the need for higher sensitivity, and two low-sensitivity zones guided the level of cutting/grading and fill material used during the construction process.
- **Pre- and Post-Construction Ecological Survey:** During the summer of 2007, PM USA worked with Virginia Commonwealth University, Department of Biology, to conduct ecological inventories where the future natural treatment system would be built. A "baseline" survey was performed to evaluate and document changes in the ecological communities associated with the site both during and after construction.[14] Surveyed elements included vegetation, mammal fauna, avifauna, herpetofauna, odonata, lepidoterans, and soil characteristics. The survey identified ecological threats to the future natural treatment facility that included potential problems such as herbivory of the wetland

A treatment cell at PM USA's Chester facility with open water and adjacent wetlands.

A pumping station at the natural treatment system used to pump effluent as needed during high flows.

vegetation from resident geese populations, deer, and other mammals. Several species of exotic and native invasive plants both on-site and in the vicinity were noted as having the potential for outcompeting both the native upland herbaceous plant species and future wetland species intended for the natural treatment system.

Engineering Feasibility Study

In September of 2005, PM USA asked CH2M HILL to evaluate the feasibility, benefits, and concerns associated with initiating a natural treatment system at the Chester facility. The consultants laid out the following objectives for the study:

- A review of the available land in the vicinity of the PM USA wastewater treatment plant to identify candidate sites;
- A description of how a natural treatment system could improve the effluent water quality, while achieving secondary benefits such as wildlife habitat enhancement and public education;
- An analysis and comparison of three conceptual designs and preparation of a preferred alternative;
- An outline of the potential planning, design, construction capital, and operational and maintenance costs associated with the project; and
- Recommended steps for moving forward.

Site Evaluations: In December of 2005, staff from PM USA and CH2M HILL conducted a workshop to narrow down the list of six candidate sites identified by the consultant. Using preliminary renderings of wetland system designs and information developed during the site reconnaissance, two areas emerged as the most logical locations. Concerns over the location of existing utilities, proximity to local residential neighborhoods, and piping challenges were cited as reasons to eliminate four of the six sites.

Review of Potential Benefits: CH2M HILL was familiar with the technical literature assessing the effectiveness of using wetlands to treat wastewater. They provided important background information that summarized the three general types of shallow vegetated ecosystems being used for water quality treatment: 1) natural wetlands, 2) constructed surface flow (free water surface), and 3) subsurface flow (submerged vegetated bed).[15] The consultants noted that although observed treatment efficiency varies by wetland type, engineered wetlands significantly lower concentrations and mass loads of biochemical oxygen demand,

total suspended solids, and total nitrogen concentrations. Removal efficiencies vary more widely for total phosphorus, metals, and organic compounds.[16] System performance is limited by the form and concentration of the constituents, amount of wetted area, water flow rates and residence time, inflow water qualities, plant communities, the presence of oxygen, substrate type, and the entire chemical makeup of the water to be treated. Engineered wetlands can be designed to regulate water depth and residence time, two important factors in treatment efficiency.[17]

In terms of ancillary benefits, CH2M HILL found that more than 800 animal species have been reported from constructed treatment wetlands. Notably, they cited that the diversity of wetland-dependant raptors and bird species—such as shorebirds, wading birds, diving birds, and waterfowl—is one of the most popular public aspects of wetland treatment systems.

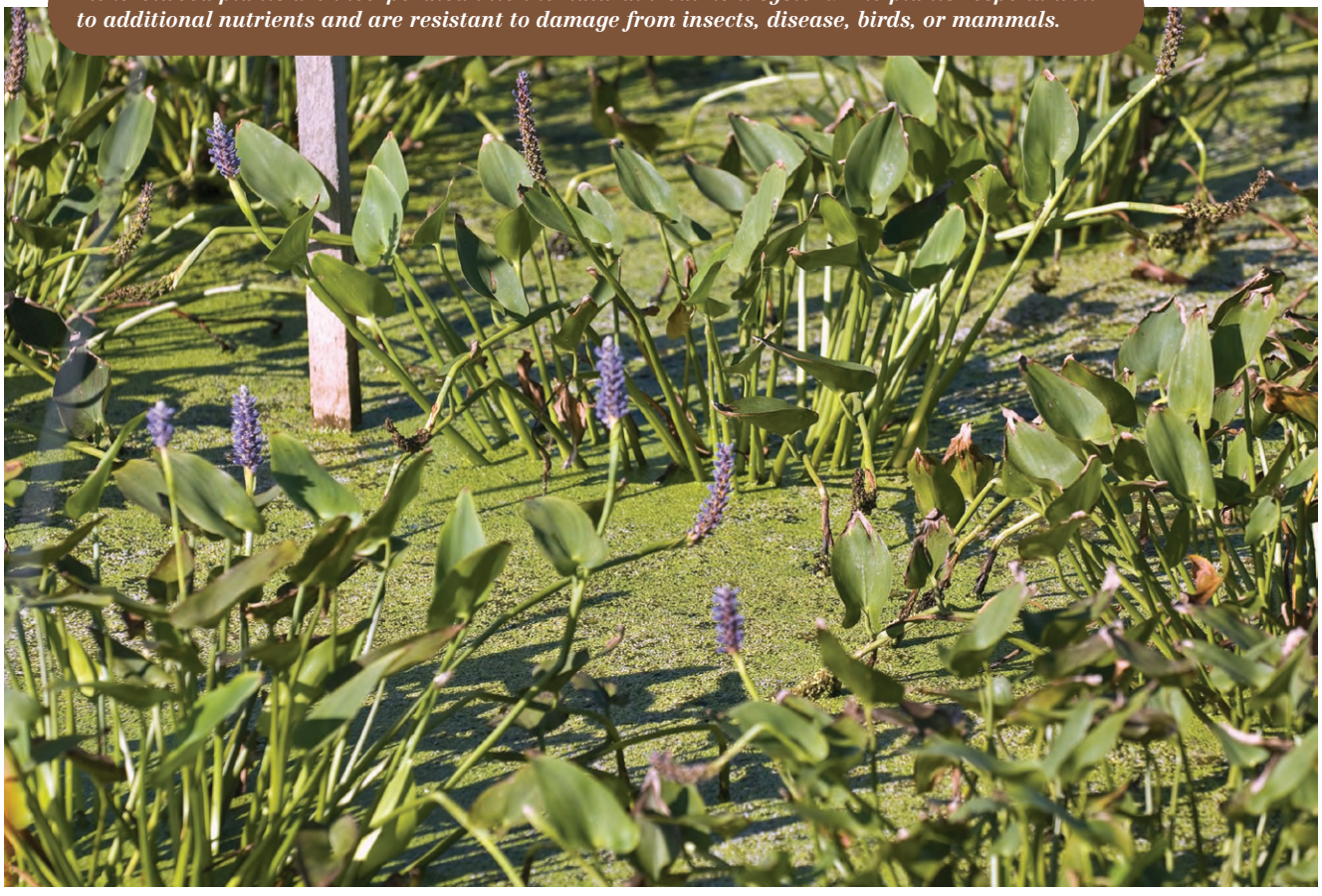
Pre-Implementation Actions: With the feasibility study completed, CH2M HILL recommended three important actions that were necessary to build the project:

- Performing a detailed hydrologic data collection and modeling analysis to confirm the preliminary groundwater infiltration rates described in their report;
- Confirming groundwater monitoring and performance criteria for the site from the Virginia Department of Environmental Quality; and
- Preparing a detailed design and construction schedule consistent with regional seasonal variation for optimum results during the wetland planting and grow-out period.

Alternatives Analysis: After PM USA decided to maximize treatment potential with a constructed surface-flow wetland, five flow scenarios were modeled. The flow scenarios ranged from 0.5 mgd up to the 3.0 mgd capacity of the plant. The wetland model was run with incrementally greater total wetland area to create a curve showing how water quality performance changes with increased area.

System Design: Based on the analysis and recommendations, PM USA chose to move forward with a constructed surface-flow wetland design. The natural treatment system, including cell sizes and boundaries, was developed using Geographic Information System (GIS) software. Wetland cells were shaped to maximize cell areas and minimize excavation volumes, which was a significant portion of the

Pickerelweed plants are incorporated into the natural treatment system. The plants respond well to additional nutrients and are resistant to damage from insects, disease, birds, or mammals.



overall construction cost. The wetland configuration was based upon general guidelines provided in Kadlec and Knight (1996)[18] and from CH2M HILL's previous wetland project experience.

The configuration uses two parallel north-south flow paths. Each flow path contains a series of three wetland cells, for a total of six separate wetlands encompassing 48 acres of wetlands on 70 acres of land. Flow from the existing wastewater treatment plant is pumped to the inlet of the wetland system. From there, water moves through the natural treatment system by gravity. The parallel treatment paths add operational flexibility to the system while the multiple cells in series improve treatment efficiencies. To ensure the wetland system performed as a surface water flow system, dense clay was used as the bottom layer of each of the cells. The system includes a series of small, deep water zones interspersed with shallow marsh zones. The marsh zone is covered with grasses and plants that grow in shallow water. The system relies on natural physical, and biological processes such as uptake and chemical synthesis to remove nutrients such as nitrogen and phosphorous. It takes an average of 9 to 14 days for the water to traverse the entire wetland system.

The vegetation used for this system was limited to native species that are readily available from local nurseries or planting contractors. There are more than 150,000 plants in the six cells of the natural treatment system. Typical species include: arrowhead (*Sagittaria latifolia*), pickerelweed (*Pontedaria cordata*), giant bulrush (*Scirpus californicus*), three square bulrush (*Scirpus americanus*), cattail (*Typha latifolia*), water lily (*Nymphaea odorata*), and spatterdock (*Nuphar luteum*). A mixture of hardwoods and evergreens were incorporated into the design for site privacy and aesthetics. In the upland areas, there are about 945 plants, including more than 350 trees such as red maple (*Acer Rubrum*), eastern redbud (*Ceris Canadensis*), dogwood (*Cornus florida*), Bald cypress (*Taxodium distichum*), sweet crabapple (*Malus coronaria*), and others. Wetland tree and shrub species were installed in locations to create resting and nesting habitat for wading birds and aquatic animals.[18]

Natural Treatment System

Schematic of the natural treatment system used by PM USA.

RESULTS

PM USA's natural treatment system is fully operational and functioning properly. The treated wastewater previously sent to the James River is now diverted to the constructed wetlands for additional treatment. The water flows through the cells and through hundreds of thousands of native plants that absorb some of the remaining pollutants. The reclaimed water from the wetlands then is returned to the James River.

PM USA is collecting data on the performance of the system and expects it to reach full potential once the wetland vegetation is fully established. Initial results observed from July 2008 to June 2009 indicate that the system has been extremely successful in removing ammonia, phosphorous, and nitrogen, although the first year of data represents a period of rapid plant growth and uptake levels that are not likely to be sustained at this level over time. It is important to note that the initial results are based on a small number of data sets; thus PM USA has characterized these results as unrepresentative of the system's long-term performance.

- **Ammonia (NH3)** - This compound can be toxic to fresh water organisms at concentrations ranging from 0.53 to 22.8 mg/L. Plants are more tolerant of ammonia than animals, and invertebrates are more tolerant than fish. Initial results indicate that PM USA has reduced ammonia concentrations in the wastewater by 91%.
- **Phosphorous** – This is a key element necessary for growth of plants and animals. Nevertheless, an excess of phosphate stimulates hyper-growth of algae and aquatic plants, which causes eutrophication and ultimately leads to low dissolved oxygen levels in the water, also known as "dead zones." Initial results indicate that PM USA has reduced phosphorous concentrations in the wastewater by 81%.
- **Nitrogen** – This is one of the most abundant elements found in the cells of all living things. Nitrogen-containing compounds act as nutrients in streams, rivers, and reservoirs. Like phosphorous, excessive nitrogen stimulates hyper-growth of algae and aquatic plants, which causes eutrophication and creates "dead zones." Initial results indicate that PM USA has reduced nitrogen concentrations in the wastewater by 36%.

Initial Pollutant Reduction Rates			
	In (ppm)	Out (ppm)	Percentage
Ammonia	0.22	0.02	91
Phosphorous	0.52	0.1	81
Nitrogen	9.6	6.16	36
Organic N	8.5	6	29
Inorganic N	1.1	0.16	85

ppm: parts per million

PM USA has worked with the Rice Environmental Center at Virginia Commonwealth University to monitor the ecological health of the system. Researchers documented the baseline ecological conditions of the fallow farm field as well as conditions before, during, and after construction. Overall, the researchers saw a large increase in the diversity of wildlife after completion of the natural treatment system. They have identified more than 37 new species using the wetland in the early months of the system's operation (18 birds, 7 reptiles and amphibians, 7 dragonflies, 4 butterflies, and 1 damselfly).

PM USA has encountered some invasive plant growth, notably purple loosestrife and common cattails. These unwanted plants are being removed until the desired plants are established. Geese can also uproot young plants, so netting was installed until the vegetation matures and takes root to prevent this from happening.

KEYS TO SUCCESS

- **Early engagement of key stakeholders.** PM USA devoted time and effort in outreach to citizen and government stakeholders. Through these efforts, critical concerns were identified in advance of the project. In the end, the time required to implement the project was reduced and the results were superior. For example, the Bermuda Hundred community initially expressed concern that groundwater may be adversely impacted from the system. While engineering studies showed that this would not be the case, PM USA responded to the neighbors' concerns by arranging to extend the Chesterfield County public water system to the Bermuda Hundred homes, which were served by well water.
- **Support from the Virginia Department of Environmental Quality.** The natural treatment system was an unconventional idea that raised many questions. An open-minded attitude and technical support from the Virginia Department of Environmental Quality gave PM USA the reinforcement needed to move forward with the project.
- **Support from corporate management.** The project clearly matched the company's environmental objectives and has served as a catalyst in improving their overall environmental management system.
- **Communication with employees.** Periodic meetings were held to inform PM USA employees on the progress of the wetland construction. This resulted in greater internal and external awareness and support for the project.
- **Project management team.** The interdisciplinary approach used by PM USA provided the full range of experts needed for success. PM USA's integrated team, including representatives from various functional areas such as environmental compliance and engineering, plant and waste water treatment management, engineering, communications, and community affairs provided leadership and expertise throughout the project.

- **The right implementation partner.** CH2M HILL was the best partner to implement the project because of their experience with designing, building, and maintaining natural treatment systems.

PHOTOS AND FIGURES

Page 243, 247-249: Photos, David Burke
Page 244: Photo, Phillip Morris USA
Page 246: Figure, Joel Dunn
Page 250: Figure from CH2M Hill 2006

REFERENCES

[1,2,3]James River Association. 2008. *State of the James River 2007*. James River Association, Richmond, VA.

[4,9,18]Kadelc, R. H. and R. L. Knight. 1996. *Treatment Wetlands*. CRC/Lewis Publishers, Boca Raton, FL. 893 pp.

[5]Odum, H.T. 1985. *Self-Organization of Estuarine Ecosystems in Marine Ponds Receiving Treated Sewage. Data from Experimental Pond Studies at Morehead City*, North Carolina, 1968-1972. University of North Carolina Sea Grant. Publication No. UNC-SG-85-04.

[6]Kaldec, R. H., W. Bastiaens and D. T. Urban. 1993. Hydrological design of free water surface treatment wetlands. In, Moshiri, G. A. (editor). *Constructed Wetlands for Water Quality Improvement*. Lewis Publishers, Boca Raton, FL. 630 pp.

[7]Ewel, K. C and H. T. Odum. 1984. *Cypress Swamps*. University of Florida Press, Gainsville, FL.

[8]Small, M. and C. Wurm. 1977. Data Report: Meadow/Marsh/Pond System. Brookhaven National Laboratory, Upton, N.Y.

[10]Reed, S. C., R. W. Crites, and E. J. Middlebrooks. 1995. *Natural Systems for Waste Management and Treatment*. 2nd Edition. McGraw-Hill, New York, NY.

[11,12,13,15]CH2M HILL. 2006. Feasibility Study: *Natural Treatment System for the Philip Morris USA Park 500 Facility*. Prepared for Philip Morris USA, by CH2M HILL, Englewood, CO.

[14]Russo, C., F. Molter and E. Crawford. 2007. *Philip Morris USA Inc. Park 500 Natural Treatment System Baseline Ecological Monitoring Results: A Data Report*. Virginia Commonwealth University, Richmond, VA.

[16]Environmental Protection Agency. 1988. *Design Manual: Constructed Wetlands and Aquatic Plan Systems for Municipal Wastewater Treatment*. U.S. Environmental Protection Agency, Cincinnati, OH. EPA/625/1-88/022.

[17]Wetland Solutions Inc. 2008. Introduction to Treatment Wetlands. Wetland Solutions Inc., Gainesville, FL. In, http://wetlandsolutionsinc.com/wwd_treatment_wetlands.html.

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Further Reading:
http://www.philipmorrisusa.com/en/cms/Responsibility/Reducing/Reducing_Our_Environmental_Impact/case_studies/NTS_Case_Study/xx

Sustainable Infrastructure at Navy and Marine Corps Installations

An Effective Approach to Controlling Stormwater Entering the Bay

The United States Department of the Navy has implemented a national policy mandating the use of low impact development techniques as well as a more sweeping Sustainable Infrastructure policy in the Mid-Atlantic region, which have made installations more environmentally and economically efficient to construct, operate, and maintain.

CASE STUDY SUMMARY

The United States Department of Defense (DoD) is the second largest landholder in the Chesapeake Bay watershed, managing 657 square miles (420,480 acres) spread among 68 installations. The Department of the Navy (Navy), lead agency for the DoD's Chesapeake Bay restoration effort, recently set a goal of no net increase in stormwater volume and sediment or nutrient loading from major renovation and construction projects. They also implemented a monumental, service-wide policy mandating the use of low impact development (LID) techniques on all installation sustainment and modernization projects.[1,2] This policy has already resulted in many LID stormwater retrofit projects that have improved water quality, particularly at installations in the Hampton Roads area of Virginia, which is within the Chesapeake Bay watershed.

The Navy's LID efforts have also led to the development of a broader Sustainable Infrastructure Program, currently being implemented throughout the Naval Facilities Engineering Command's (NAVFAC) Mid-Atlantic Region, which uses best available practices at installations to make facilities more environmentally and economically efficient to construct, operate, and maintain. This program integrates environmental stewardship into all capital improvements, public works management and energy management. The installation of LID practices is one main component of the program and a good example of on-the-ground implementation. The Navy's LID policy is applicable to any development entity interested in stormwater practices that provide excellent treatment and discharge volume reduction. The Sustainable Infrastructure Program can be applied at a large company, government agency or organization, or even a small town seeking to improve the life cycle efficiency of its facilities.

RESOURCE MANAGEMENT CHALLENGE

The Navy manages 40 installations in the Bay watershed and each installation can have hundreds to thousands of buildings, miles of roads, acres of parking lots, airports, ship docks, power plants, and sewage treatment facilities, which serve hundreds of thousands of

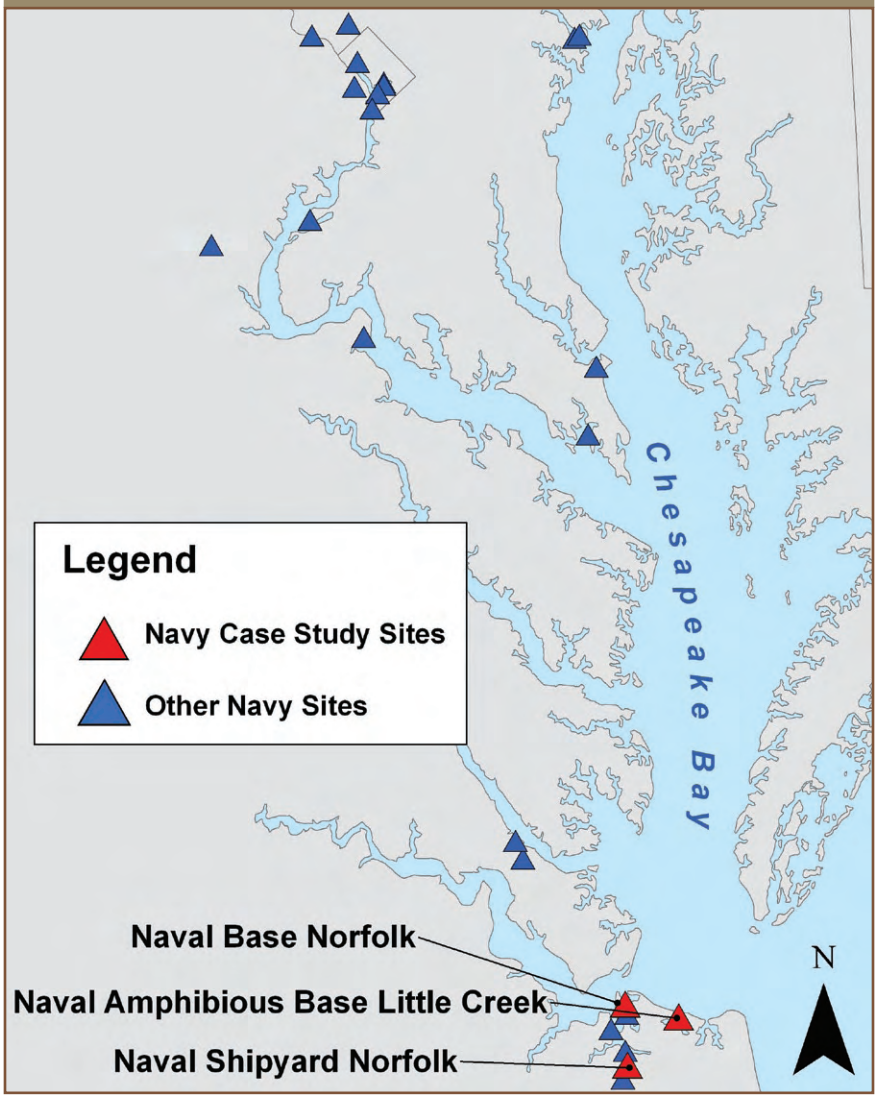
Low Impact Development

Low Impact Development (LID) reduces the impacts of land use changes associated with development on hydrology, water quality, and aquatic resources.

LID implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source.[3]

The main principle behind LID is to use runoff prevention and control options to engineer a site so that it functions hydrologically as though it is naturally vegetated or forested after development.

Chesapeake Bay Naval Facilities



people. The implementation of Base Realignment and Closure and other installation upgrades and modernization measures have resulted in significant construction activity at Navy installations. This construction activity presents challenges and opportunities for the sustainability of the Chesapeake Bay.

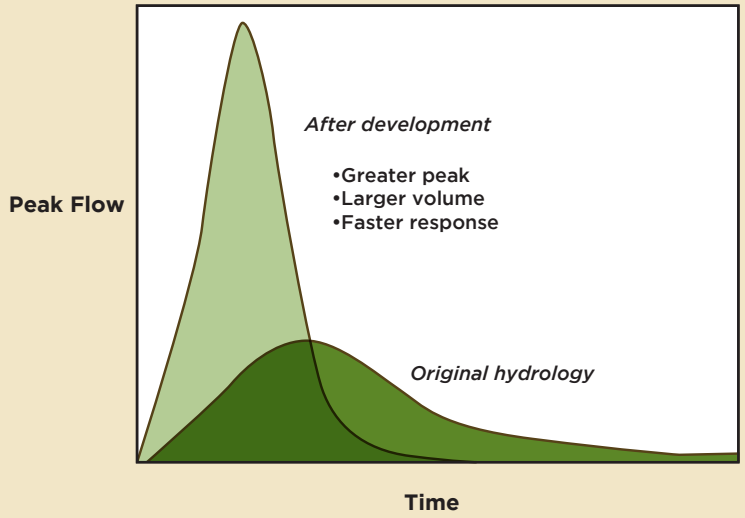
Typically, new construction decreases natural vegetation cover and drainage capacity and increases impervious surfaces (roofs, lawns, driveways, roads, parking lots and other hard surfaces). These changes typically alter an area's hydrology and result in higher peak flows and greater volumes of stormwater runoff into nearby waterways, as shown in hydrology curves. Bay-wide development in the watershed is increasing impervious surfaces at a rate four times greater than the rate of population growth.[4] From 1990 to 2000, the area of land covered by impervious surfaces in the Bay watershed increased by 40 percent. These factors have made urban and suburban stormwater runoff the fastest growing source of pollution to the Bay and the only type of pollution that continues to increase.[5] In addition, new construction typically adds to the inventory of conventional stormwater collection and conveyance infrastructure, which is a major focus of the Bay restoration effort.

Continuing water quality problems have prompted the US Environmental Protection Agency to begin developing mandatory treatment and control of stormwater through the use of Total Maximum Daily Loads (TMDL), which are essentially a clean-up plan for the Bay and its tributary rivers. In a nation-wide effort to reduce impacts to water quality, that will also help the Navy prepare for future stormwater regulations in the Bay, the Navy developed an LID policy that offers a suite of Best Management Practices (BMPs) to maintain or restore predevelopment hydrology. It mitigates the adverse effects of construction projects on water quality by cost effectively reducing the volume and pollutant loadings of stormwater before it reaches the receiving water bodies. LID utilizes strategies that infiltrate, filter, store, evaporate, and/or retain runoff close to its source. LID further reduces installation reliance on aging stormwater management infrastructure. The Navy holds state stormwater discharge permits for most of its facilities in the Bay watershed. In Virginia, the more industrialized parts of the facilities have monitoring requirements and screening values that must be met. The Navy has been exploring the use of LID retrofits to achieve these screening values.

CONSERVATION VISION

The DoD is an active participant in the Chesapeake Bay Program and in recent years has made a significant commitment to conserving, preserving and restoring the Bay.[6] The origins of the Navy's mandatory LID policy can be traced back to DoD efforts to implement innovative stormwater management practices as set forth in the Chesapeake Bay Executive Directive for managing stormwater on

Before and After Development Hydrology Curves



Graph showing the difference between peak flows given an area's original hydrology and in one where development has altered the hydrology creating intense stormwater runoff.

state and federal lands (see text box). The overall goal of the LID policy is no net increase in stormwater volume and sediment or nutrient loading from major renovation and construction projects. In order to support this goal, as well as reduce reliance on conventional stormwater collection system and treatment options, this policy directs the Navy to consider LID in the design for all projects that have a stormwater management element.

NAVFAC Mid-Atlantic's efforts to improve their environmental performance are now being expanded from stormwater management to include all infrastructure with the intent to conserve natural resources, in the Sustainable Infrastructure Program. Many environmental issues, such as stormwater pollution, climate change, energy independence, and habitat restoration were previously being addressed through disparate processes and budgets. NAVFAC Mid-Atlantic recently set a goal to integrate environmental stewardship, capital improvements (new construction or renovation), public works management, and energy production and use. They are changing traditional facilities and environmental management to include sustainability as a major objective. This new approach requires the collaboration and integration of designers, planners, facility managers and maintenance personnel. The LID policy and projects have set the stage for the Sustainable Infrastructure Program, and have set the Navy and the DoD on a course that supports their mission to defend the country as well as protect our natural and cultural resources.

IMPLEMENTATION RESOURCES

The initial LID retrofit projects at Norfolk Naval Shipyard and Naval Station Norfolk cost $140,000 and included 9 stormwater planters and three bioretention areas, and were funded by the DoD Legacy Program, which is reserved for projects that demonstrate leadership in environmental protection and restoration. The remaining retrofit projects included two bioretention areas at both Naval Station Norfolk and Navy Amphibious Base Little Creek and were funded with $250,000 of environmental compliance funding that is used to maintain compliance with stormwater discharge permits. The largest LID project to date has been construction of 13 bioretention areas at a cost of $400,000. Treatment was required for the stormwater from the impervious area created by capping an old construction debris landfill.

The Navy's LID policy requires implementation of LID techniques on all major construction projects by 2011 with encouragement for implementation in 2008 through 2010. NAVFAC Mid-Atlantic has chosen to implement

Managing Stormwater on State, Federal and District-owned Lands and Facilities

This Chesapeake Bay Executive Council adopted a commitment to set an example for local governments and private land owners by demonstrating how to develop, fund, and implement innovative stormwater management approaches and technologies on their own lands and facilities in Directive No. 01-1.[7]

This influential Directive was focused on the implementation of management and physical practices that comprehensively address all stormwater related issues, including flow volume and velocity, pollution loads, stream channel integrity, groundwater recharge, and flooding.

LID on all construction projects starting in 2009. Implementation of LID on construction projects is funded with military construction program funding for major projects and with operations and maintenance funding for smaller projects. The Navy has incorporated bioretention areas and tree box filters into most of its recent projects and is currently evaluating the use of permeable pavement and green roofs.

The LID retrofit projects were designed by CH2M Hill, an engineering consulting firm, and constructed by Agviq and Shaw, construction contractors. NAVFAC staff were able to develop the expertise necessary to oversee the projects through attendance at professional development conferences and research on various university (North Carolina State, University of New Hampshire, University of Maryland) and nonprofit organization websites (LID Center, Center for Watershed Protection, U.S. Green Building Council). To gain the expertise needed to implement the LID policy on new construction projects, NAVFAC has contracted with URS consultants and the Low Impact Development Center to provide training for its planning, design, environmental, and maintenance staffs.

CONSERVATION STRATEGY

Implementation of the Navy's LID policy at NAVFAC Mid-Atlantic is taking place under the larger umbrella of the Sustainable Infrastructure Program, which seeks to deliver sustainable facilities with a lower total life cycle cost than conventional designs through a concept they call total ownership costs. The Sustainable Infrastructure Program includes a process of understanding the baseline of natural and cultural resources on site, recognizing that most ecosystems extend beyond the property boundaries, locating projects where they minimize impacts to the ecosystem processes and finally maximizing the LID opportunities to maintain the natural hydrology of a site. LID is an important part of this emerging process.

Low Impact Development (from CH2M Hill 2002)[8]: LID denotes a wide array of measures intended to limit the cumulative effects of land development and related activities on hydrology, water quality, and aquatic resources. The integration of these measures begins with project conception, through design and construction, and continues after the site is operational. The main principle behind LID is to engineer a site so that it functions hydrologically as though it is naturally vegetated or forested after development. By focusing on the site's hydrology, this natural systems approach to development reduces runoff volume and provides mechanisms for pollutant removal.

LID encompasses numerous runoff prevention and control options. Essentially, these could be any combination of site planning and engineering control measures to minimize, infiltrate, evapotranspire, retain, detain, slow down, and treat stormwater. These measures attempt to protect and/or restore a watershed's natural functions and maintain groundwater recharge, baseflow, storage, and peak flow attenuation.

Another characteristic of the LID approach is management of stormwater at the source through the use of micro-scale controls distributed throughout the site, often as part of landscaping. Conventional stormwater management focuses on fast collection and drainage in closed conduits and end-of-pipe controls such as ponds. In contrast, LID uses reduced imperviousness, open channel sections, flatter grades, artificial storage, disconnection of flowpaths, and landscaping to slow down runoff and maximize infiltration opportunities.

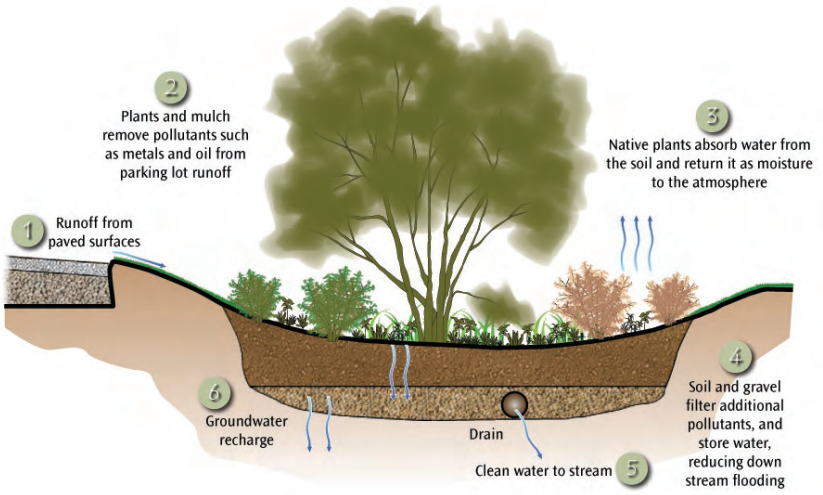
Most control measures accomplish a primary function but can fulfill one or more additional runoff control features. All of the LID controls remove pollutants from runoff through a variety of mechanisms. A large amount of pollutants are adsorbed onto soil particles and mobilized as part of suspended solids. These pollutants are removed through filtration as the water moves through vegetative covers and percolates in the soil but also by settling in the control devices. Other pollutants are removed through phytoremediation—biological uptake in the root zone of vegetation.

Summary of LID Stormwater Control Options (From CH2M HILL 2002)[9]: Five types of LID stormwater control techniques or LID BMPs that are commonly used are described below. They are bioretention, bioswales, foundation planters, permeable pavement, and green roof systems.

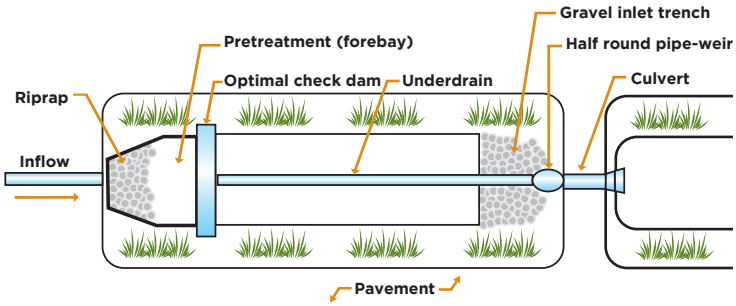
Bioretention: This stormwater control technique typically involves the use of a shallow depression that is planted with vegetation, often called a rain garden. The bioretention facilities reduce runoff volume mostly through infiltration and detention. For water quality control, bioretention combines physical filtering and adsorption with biological processes. Bioretention facilities can be located in a parking lot, at the center of each parking row and at the edge of the parking lot. They also can be located in existing green areas, treating runoff from surrounding streets, buildings, and parking lots. Bioretention facilities sometimes do not have a subsurface drain and are not typically designed as a conveyance system.

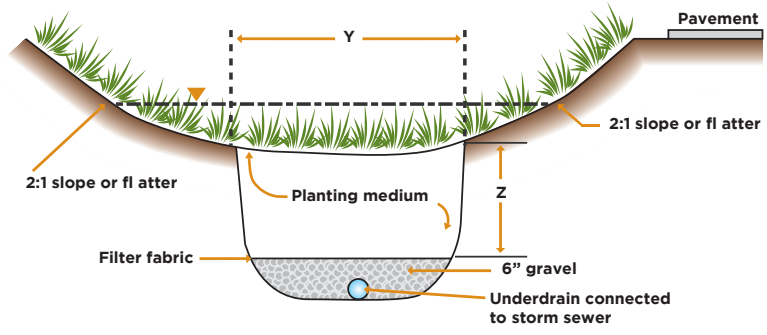
Bioswales: This stormwater control technique is typically used in residential and commercial developments

Bioretention Facility Conceptual Drawing



Bioswale Facility Conceptual Drawings





TOP: ***Bioswale facility—aerial view.***
BOTTOM: ***Bioswale facility—cross sectional view.***

as well as along highway medians as alternatives to, or enhancements of, conventional storm sewers. Bioswales remove pollutants from urban storm-water by filtration through grasses and other vegetation and infiltration through soil. Bioswales are designed to be part of a conveyance system and have relatively gentle side slopes and shallow flow depths.

Foundation Planters: This stormwater control technique uses a planter (concrete box or landscaping block) constructed along a building's exterior to treat rooftop runoff. It involves diversion of stormwater flows from the gutter/downspout system into to the planter, which is then treated by the vegetation and soil in the planter. Typical native landscape plants (shrubs, ornamental grasses, and flowers) are used as an integral part of the system. A foundation planter consists of the container, vegetation, mulch layer, soil layer, and underdrain system. The underdrain system can be connected to an existing stormwater system or allowed to drain onto the sidewalk or street. Other sources of water, such as cooling-system condensate, can also be diverted to the foundation planter.

Permeable Pavement: This stormwa-ter control technique uses materials designed primarily to reduce the imperviousness of traffic surfaces, such as patios, walkways, driveways, and parking areas, by increasing infiltration and reducing surface runoff. Permeable paving materials include porous bituminous concrete mixtures, permeable interlocking concrete paving blocks, concrete grid pavers, perforated brick pavers, and gravel or grass engineered to prevent compaction. These porous paving systems are also used as inlets and covers for infiltration trenches. A base course serves as a storage layer. Permeable pavement can be effective at reducing peak surface runoff rates

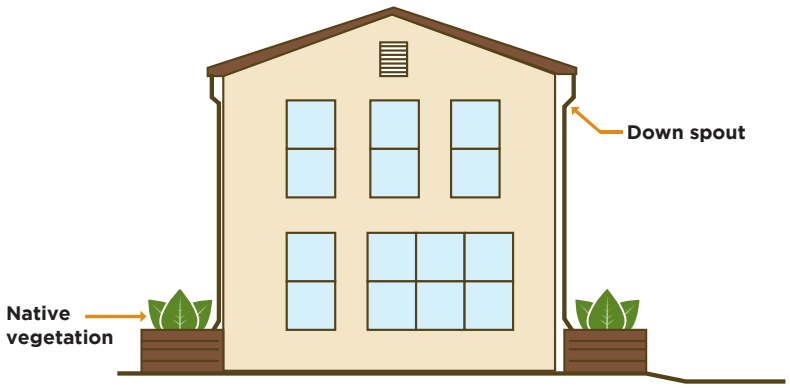
and at improving the groundwater recharge characteristics of developed sites.

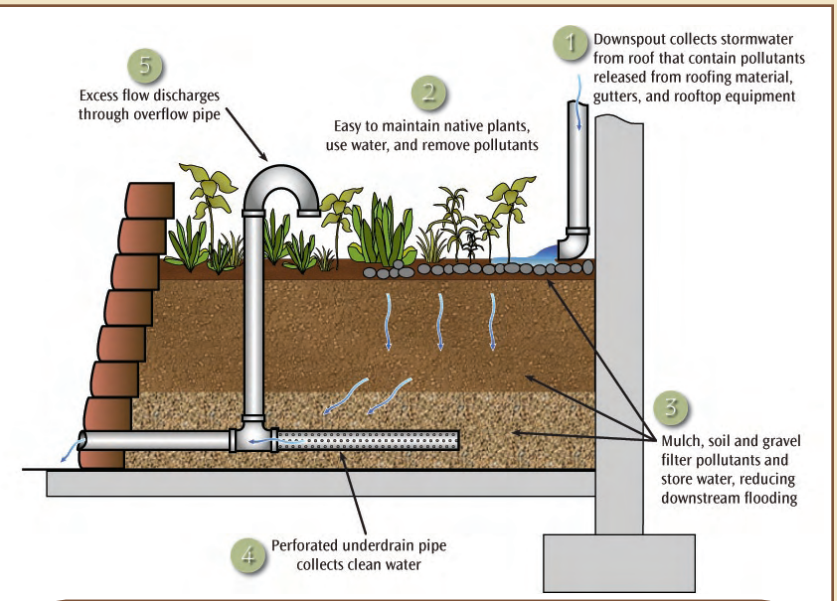
Green Roof Systems: This stormwater control technique is a form of rooftop runoff management. Rooftop management is the modification of conventional building design—using vegetated roof covers, roof gardens, vegetated building facades, and roof ponding areas—to retard runoff from roofs. Managing rooftop runoff provides substantial benefits in highly urbanized settings where space for other BMPs is limited. In these cases, rooftop measures may be the only practical alternative for relieving pressure on overtaxed storm sewer systems. In addition to achieving specific stormwater runoff management objectives, rooftop runoff management is also aesthetically and socially beneficial. These measures are suitable for flat or gently sloping roofs and the techniques can be retrofitted to many conventionally constructed buildings. Steep roof slopes can be retrofitted with roof gardens, although the cost is higher.

RESULTS

In 2002, the Navy funded a study by CH2M Hill to assess opportunities to implement LID techniques at the Norfolk Naval Shipyard.[10] The study recommendations were used to select demonstration sites for implementation at the shipyard. The Navy staff also identified some additional demonstration sites at the Naval Station Norfolk and Naval Amphibious Base Little Creek. Initial LID projects were retrofit sites chosen specifically to improve stormwater discharge quality at outfalls where stormwater discharge permit screening values were being exceeded. Projects were completed at Norfolk Naval Shipyard in 2005, at Norfolk Naval Station in 2006 and 2008, and at Naval Amphibious Base Little Creek in 2008. These projects have resulted in the installation of bioretention areas, bioswales, and stormwater planters and are managing stormwater from approximately 17 acres of land/rooftop. NAVFAC is currently evaluating the use of permeable pavements and green roofs.

Foundation Planter Conceptual Drawings





TOP: ***Building with foundation planters intercepting rooftop runoff.***
BOTTOM: ***Cross sectional view of foundation planter.***

Norfolk Naval Shipyard: With approximately 800 acres of land and 4 miles of waterfront, Norfolk Naval Shipyard is the largest Navy shipyard on the east coast. It is located in the City of Portsmouth, Virginia, on the southern branch of the Elizabeth River which flows into the James River and ultimately the Bay.

The Shipyard demolished an abandoned rail line and replaced it with a rain garden that treats runoff from adjacent parking areas and roadways that drain to an outfall that has historically had elevated heavy metal concentrations. Nine stormwater planters were also installed at the Norfolk Naval Shipyard. These planters are large containers installed at a building's downspout to capture and treat rooftop runoff. They contain plants, mulch, and soil that treat the runoff before discharging it through an under drain system to the underlying pavement and ultimately to nearby storm drains.

Hampton Roads Naval Facilities

In addition to helping meet the goals of the 2001 Chesapeake Bay Executive Council directive on stormwater, the implementation of LID practices at the Shipyard helps them meet their National Pollutant Discharge Elimination System (NPDES) stormwater permitting requirements and demonstrates the installation's leadership in the use of environmentally friendly stormwater management practices.

Naval Station Norfolk: Naval Station Norfolk is the world's largest naval complex. It is located on 3,400 acres of land in the City of Norfolk, Virginia near the mouth of the Elizabeth and James Rivers which drain into the Chesapeake Bay. It includes a naval seaport, naval air field (Chambers Field), and the Naval Support Activity (which includes the headquarters of the U.S. Joint Forces Command and Combined Fleet Forces Command) as well as the Navy Staff College.

In 2006, the Station installed a rain garden adjacent to a large parking lot located in front of several aircraft maintenance hangers. The rain garden now treats polluted runoff from a 72,665 square foot parking lot in front of the hangars. The runoff

NORFOLK NAVY SHIPYARD
LEFT: *A bioretention facility, that was formerly an abandoned railroad line, built for treating street runoff.*
RIGHT: *Stormwater planters treat rooftop runoff from a public works vehicle maintenance building.*






Naval Station Norfolk

The upper left photograph features the parking lot for aircraft hangars and vegetated drainage swale on adjacent land before construction of a rain garden. The upper right is a photo of the rain garden three years after construction. The middle left features the parking lot next to a fast food court before construction of a rain garden. The middle right is a photo of the rain garden one year after construction. The bottom left photograph features the steam plant before construction of a rain garden. The bottom right is a photo of the rain garden less than two months after construction.

flows through the rain garden and is discharged through an under drain to a monitoring structure before it enters Willoughby Bay. That same year, the Naval Station also installed a rain garden and a stormwater planter at a building site. The rain garden was put in between the installation's steam generation plant and the scrap metal yard and treats runoff from a drainage area of approximately 8,100 square feet. Wax myrtle *(Morella cerifera)*, common winterberry *(Ilex verticillata)*, ink berry *(Ilex glabra)*, and St. John's wort *(Hypericum sp.)* were planted to treat the runoff. A stormwater planter was also installed to treat some of the rooftop runoff by diverting it from the downspout system to the planter.

In 2008, the Station installed a rain garden next to the parking lot of a fast food court. This garden was sized to treat rainfall from 22,468 square feet of parking lot drainage area. Another rain garden was installed in 2008 at another steam plant to treat runoff from approximately 11,500 square feet of the building's roof.

In 2008, the Station also installed 13 separate bioretention areas at a retired 13-acre landfill in the northwest section of the base. The Station partnered with the Virginia Department of Environmental Quality and EPA Region 3 to cap the area with a 10 acre asphalt cap that can be used as a parking lot. To capture the site's stormwater, the installation constructed several rain gardens instead of building the traditional stormwater management pond. To build the rain gardens, the installation excavated the ground and put in a sand and soil mixture and plants that will work together to capture and filter stormwater runoff. The installation installed under drains in conjunction with eleven of the rain gardens to convey the filtered water to the Bay. The two rain gardens closest to the Bay do not have underdrains since they are located outside the footprint of the former landfill and have sandy soils that are capable of infiltrating the flow.

Naval Amphibious Base Little Creek: Little Creek provides support and services to operating forces and shore commands. It has 2,120 acres of land and 8 miles of waterfront. It is located in the City of Virginia Beach, Virginia, near the mouth of the Bay.

The Base removed an old building and storage tank and built a parking lot that included an infiltration basin in the middle of the lot. This facility detains large influxes of stormwater and includes a sand bottom, which removes up to 35% of pollutants from the runoff. The facility is lined with crepe myrtle *(Lagerstroemia indica)* and live oaks *(Quercus virginiana)*. The Base also created two bioretention facilities adjacent to a maintenance facility that captured pollutants from pressure washing operations and stormwater and filters it before releasing it to the Bay. The Base won a pollution prevention award from the Hampton Roads Sanitation District as a result of their LID projects.

Educational Signs: Educational signs were installed at all LID best management practice retrofit sites at the Norfolk Naval Shipyard and at Naval Station Norfolk to teach people about low impact development projects, stormwater management, and the importance of protecting the Bay.

The Navy has found that LID stormwater management practices are more effective than other techniques, easier to maintain, and provide the dual function of landscape aesthetics. As the Sustainable Infrastructure Program is implemented, Navy buildings will be more energy efficient, environmentally sound, and less expensive to operate and maintain.

KEYS TO SUCCESS

Authorization: Leadership from the Deputy Assistant Secretary of the Navy Environmental Office in devel-

NAVAL AMPHIBIOUS BASE LITTLE CREEK
LEFT: ***An infiltration basin between two parking lots that captures runoff.***
RIGHT: ***A bioretention facility adjacent to a maintenance facility was installed to reduce metals in runoff.***

oping and adopting the LID Policy has enabled the program to move beyond the demonstration project phase by requiring that LID be considered on major projects.

Funding: The installation of innovative management practices to meet stormwater discharge permit screening values and efforts to comply with the Chesapeake Bay Executive Council Directive on Stormwater Management requires adequate funding for LID projects. Such funding can be direct or the result of savings from the elimination of traditional stormwater management practices.

Assimilation: The Navy had to find suitable candidate sites and overcome many institutional barriers to successfully complete the demonstration projects including traditional practices of regulatory agencies and the construction industry. They also had to use innovative design ideas to solve potential utility system conflicts resulting from construction.

Implementation: Success in implementing the LID policy and development of the Sustainable Infrastructure Program is attributed to the vision and leadership of the men and women of NAVFAC Mid-Atlantic workforce. Funding of initial LID training of planners, designers, and maintenance staff by NAVFAC HQ and follow up training funded by NAVFAC Mid-Atlantic have also been instrumental in successful implementation of the policy.

PHOTOS AND FIGURES

Page 253, 261: Photos, Joel Dunn
Page 254, 259: Figures, Burke Environmental Associates/The Conservation Fund
Page 255: Figure, CH2M Hill 2002
Page 257, 258: Figures, US Navy
Page 259: Photos, US Navy
Page 260: Photos, US Navy; except top right and center right, Joel Dunn

REFERENCES

[1]Department of the Navy. 2007. Department of the Navy Low Impact Development (LID) Policy for Stormwater Management. Memorandum for Deputy Chief of Naval Operations, Fleet Readiness and Logistics (November 16, 2007), Deputy Commandant of the Marine Corps (Installations and Logistics).

[2]Lutz, L. 2008. Navy launches policy to stem tide of stormwater: All new construction and major renovations will require low impact development techniques. *Bay Journal* (January 2008). Seven Valleys, PA. Available online at: http://www.bayjournal.com/article.cfm?article=3235.

[3]Prince George's County Department of Environmental Resources. 1999. *Low-Impact Development Design Strategies, An Integrated Design Approach*. U.S. Environmental Protection Agency, Washington, D.C. EPA 841-B-00-003.

[4,6]Department of Defense. 2007. *Defending Our National Treasure: A Department of Defense Chesapeake Bay Restoration Partnership 1998–2004*. IAN Press, Cambridge, ME. 176 pp.

[5]Environmental Protection Agency. 2009. Federal Bill Would Improve Stormwater Runoff Management in Chesapeake Bay Region. Environmental Protection Agency, Annapolis, MD. In, http://www.chesapeakebay.net/news_runoffbill09.aspx?menuitem=41576.

[7]Chesapeake Executive Council. 2001. Managing Stormwater on State, Federal and District-owned Lands and Facilities. Directive N0. 01-1. Available online at: http://www.chesapeakebay.net/content/publications/cbp_12105.pdf.

[8,9,10]CH2M Hill. 2002. Norfolk Naval Shipyard Low Impact Development Assessment. Prepared for the U.S. Navy by CH2M HILL, Englewood, CO.

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Controlling Exotic Invasive Plants in Parks and Natural Areas

A Site-Based and Weed-Based Approach in the Anacostia Watershed

Volunteers with the Anacostia Watershed Society are driving a strategic attack on exotic invasive plant species that has already made dramatic improvements by removing half the invasive plants on more than 802 acres at 23 sites in the Anacostia River watershed.

CASE STUDY SUMMARY

Exotic invasive plant species are one of the biggest threats to biodiversity and ecosystem function in the Chesapeake Bay watershed. Removal of invasive plant populations in nature reserves and parklands improves habitat quality for native species, protects the natural heritage of the Chesapeake region, and creates a better environment for public recreation. The Anacostia Watershed Society has developed an innovative method to eradicate and control exotic invasive species in public parks in the Anacostia River watershed.

The Anacostia Watershed Society is a local non-profit organization working on community-based environmental education, ecological restoration, and advocacy programs to protect and restore the Anacostia River watershed. Its mission is to make the river and its tributaries swimmable and fishable, in keeping with the Clean Water Act, for the health and enjoyment of everyone in the community. In addition to managing the extensive invasive plant control program, the organization's restoration programs also involve reforesting open lands, restoring wetlands, removing pollution, and stabilizing stream banks in the sub-watersheds.

Multifora rose, an exotic invasive species.

The Anacostia River flows about 20 miles from its headwaters in Prince George's and Montgomery Counties in Maryland to the Potomac River in Washington, D.C. It is the most densely populated watershed in the region with 1.1 million people and predominantly urban and suburban land use. The wooded parks in the watershed have a particularly serious problem with more than 21 exotic invasive plants, such as kudzu (*Pueraria lobata*), multiflora rose (*Rosa multiflora*) and Japanese honeysuckle (*Lonicera japonica*). In an effort to improve community stewardship of the river and the environmental health of the Anacostia River watershed, The Anacostia Watershed Society has developed an Exotic Invasive Plant Species Control Program (IPSCP).

The IPSCP is a long-term project that engages local residents in a coordinated effort to remove invasive plant species from parks in the watershed. The program was designed in 2005 by Dr. Marc Imlay, a conservation biologist with extensive experience with invasive plant species. The IPSCP uses site-based and weed-based approaches that involve targeted herbicide application, hand removal, hand removal with tools, bagging, and re-vegetation. The site-based approach aims to eradicate all invasive plants from a particular park, whereas the weed-based approach focuses efforts on the most significant exotic invasive plants in a park. Since teaming up with Dr. Imlay, the Anacostia Watershed Society has removed approximately 47 acres of invasive plants and tackled 21 highly invasive species in seven parks throughout the watershed.

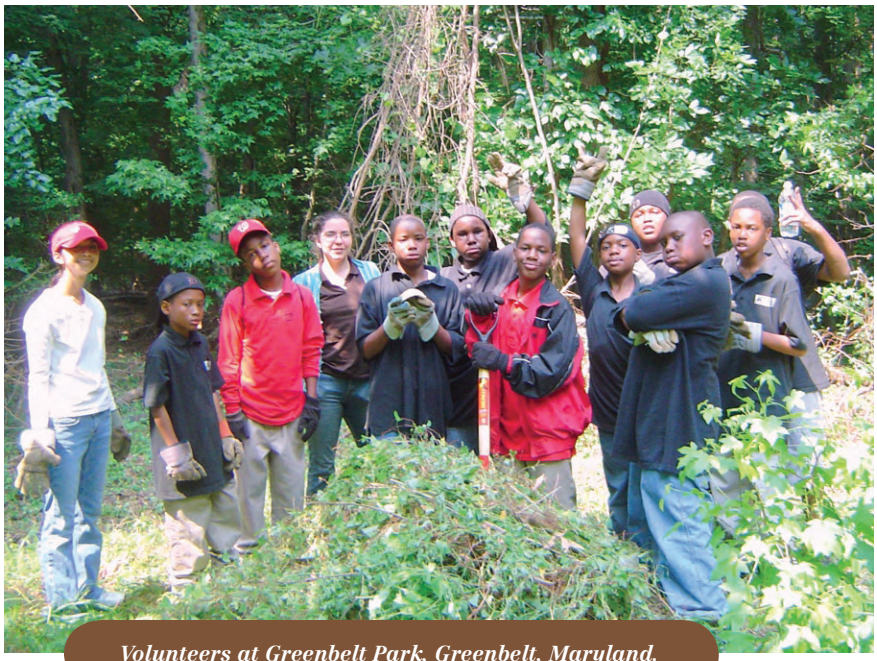
RESOURCE MANAGEMENT CHALLENGE

The ecological impacts of biological invasions caused by exotic invasive species are massive. Invasive species can eradicate native flora and fauna and destroy natural habitat, which leads to the degradation of ecosystem functions by disrupting ecological processes. Hundreds of species extinctions can be attributed to the spread of exotic invasive species throughout the world.

Uncontrolled exotic invasive species can also result in substantial costs to the economy by affecting agriculture and landscaping infrastructure. The globalization and increase in international trade and tourism provide unprecedented opportunities for species to be spread accidentally and deliberately.[1] Moreover, ornamental plant nurseries are still selling highly invasive plant species that lead to wide-spread intentional propagation of the destructive plants.

Anacostia Watershed

The Mid-Atlantic region of the United States has been subject to a serious biological infestation of more than 200 exotic invasive plant species.[2] Most of the plants are native to Asia and Europe and were brought to the region either purposefully, for use in horticulture or erosion control, or accidentally through trade or tourism. These plants now successfully reproduce in areas throughout the Chesapeake Bay watershed and often have no natural predators to keep their populations in check. Invasive plants often do well in fragmented habitats with lots of edge, which allows for light penetration and propagule distribution either by wind or animals. The remaining forests in the Anacostia watershed, which cover approximately 25% of the landscape in a matrix of urban/suburban land use, are irregular, scattered, and often invaded by non-native highly invasive plant species. The fragmented urban forest patches remaining in the Anacostia river watershed have been considerably damaged by invasive plant species populations. The negative impact on the native biota is striking and in need of rapid attention.



Volunteers at Greenbelt Park, Greenbelt, Maryland.

CONSERVATION VISION

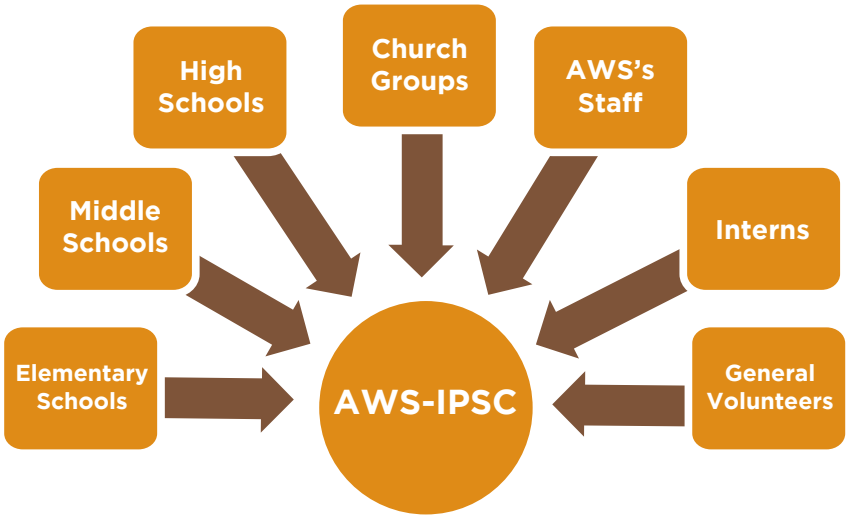
Exotic invasive plant species cover many parks and natural areas in the Anacostia River watershed that the conservation movement has been trying to protect from habitat destruction and other anthropogenic disturbances. In 2005, Dr. Marc Imlay proposed that Anacostia Watershed Society lead a stewardship program focused on controlling exotic invasive species in these parks and natural areas. Dr. Imlay has worked in Hawaii and North Carolina on invasive plant species and was pleased to share his experience. He proposed scientifically rigorous methods, which employed a combination of site-based and weed-based control approaches to tackle the invasive plant populations. The Anacostia Watershed Society assembled the program and engaged community members of all ages and backgrounds in its extensive volunteer network in the effort. Through their countless hours of hard work, these volunteers have dramatically reduced exotic invasive plant species populations in the watershed.

IMPLEMENTATION RESOURCES

The progress made to date on this innovative program has an equivalent cost of approximately $433,000. Volunteer labor was valued at $18/hour and AWS staff at $22/hour. Of this total, approximately $400,000 represents volunteer contributions and $33,000 were AWS staff hours. The labor is equivalent to 3,000 work days performed from 2005 to 2008. The program has been financed by grants from eight organizations: the Bancroft Foundation; Morris and Gwendolyn Cafritz Foundation; Horning Family Fund; Curtis and Edith Munson Foundation; National Fish and Wildlife Foundation; Maryland-National Capital Park and Planning Commission; U.S. Environmental Protection Agency; and the Morningstar Foundation.

The Anacostia Watershed Society has also received important advice for the program from the following experts: Dr. Sara Tangren (Department of Plant Sciences and Landscape Architecture, University of Maryland), Dr. Karen Prestegaard, (geologist, University of Maryland); Del Fanning (soils scientist, University of Maryland), Dr. Michele Dudash (entomologist, University of Maryland), and Mike Donovan (ornithologist). Joe Metzger, a botanist from the Maryland Native Plant Society, has also helped to identify plant species throughout the watershed.

The many hours of volunteer service are crucial to the program's success. As part of the Anacostia Watershed Society's environmental education program, students from elementary, middle, and high schools have been a major component of the volunteer workforce. This provides the students with both classroom and hands-on field experience, adding depth to their educational experience and strength-



Before and after the removal of kudzu from a sapling in a reforested area along the Northwest Branch of the Anacostia River Hyattsville, Maryland.

ening the invasive species control program. In addition, volunteers from church groups and concerned citizens have donated substantial amounts of their time.

CONSERVATION STRATEGY

The IPSCP controls invasive plants through a combination of site-based and weed-based strategies. The site-based strategy focuses on the removal of all exotics from a given site for the purpose of protecting keystone biotic resources (threatened species populations, fragile habitats, etc.) from the harmful impacts of exotic invasive species. The weed-based strategy directs limited resources to the worst invasive species, such as lesser celandine (*Ranunculus ficaria*) or English ivy (*Hedera helix*). With both methods, the Anacostia Watershed Society uses an iterative or adaptive management process—a "learn by doing" approach that results in better ways to implement the program at different sites and with different focal species. An important component of the program has been the incorporation of an early detection/rapid response approach. Early detection/rapid response includes surveillance, identification, risk assessment, and quick response to new invasions of exotic plant species.[3] The discovery of the rapidly expanding wavyleaf basketgrass (*Oplismenus hirtellus ssp. undulatifolius*) in 2005 at Little Paint Branch Park in Beltsville, Maryland, was an example of early detection/rapid response for the protection of natural protected areas. The plants were quickly controlled in the park, protecting native species and existing habitat.

Removal Methods and Research

Hand removal: Hand removal is the preferred method because it is harmless to the environment and draws public attention towards the problem of invasive exotic species. Hand removal is also simple for people of most ages to perform and can be effective for most invasive species. Nevertheless, this technique requires substantial volunteer effort and can be difficult when dealing with spiny species like wineberry (*Rubus phoenicolasius*) or multiflora rose (*Rosa multiflora*). Plants must be removed with the entire root system because some of the species may have the ability to sprout from underground stems and root fragments. It is critical to use this method before the fruits and seeds have matured and dispersed. Hand-removed biomass of species such as English ivy (*Hedera*

The removal of invasive exotic plants at Cherry Hill Park, College Park, Maryland.

helix) or multiflora rose (*Rosa multiflora*) is usually left in one on-site pile to decompose.

Hand removal with tools: This method has been used to pull out stout shrubs like bush honeysuckle (*Lonicera x spp.*), trailing plants like periwinkle (*Vinca minor*), or plants that have subterranean stems, such as lesser celandine (*Ranunculus ficaria*). The entire root system of the plant can be pulled out using a four-pronged spading fork when the soil is wet. The uprooted invasive species can then be piled up and left on site.

Bagging: For plant species that have the ability to sprout easily, the hand-pulled plants are bagged, removed from the site, and dumped. Contractor bags are preferred due to their toughness and resistance to tearing. The fruits of some species like porcelainberry (*Ampelopsis brevipedunculata*) are also bagged and properly disposed.

Targeted herbicide application: The Anacostia Watershed Society uses carefully targeted, federally approved, biodegradable herbicides, such as glyphosate, in natural areas. Glyphosate is an agrochemical that usually bonds to soil particles, which prevents excessive leaching and uptake by non-target plants. Instead of spraying the foliage of invasive woody plants such as tree of heaven, Norway maple, and Chinese privet, which is normally unpractical, a concentrated herbicide solution is injected into the tree either by basal bark, hack and squirt, or cut stump. The use of herbicides as a component of exotic invasive species control has been essential in the improvement of these efforts through greater efficiency and, therefore, impact. Expanded use of herbicide is sometimes necessary when large numbers of volunteers are not available. The application of herbicides is only carried out by trained, adult personnel.

Biological Control: This method involves the use of living organisms, such as predators, parasitoids, and pathogens, to control invasive exotic species. The biological control agent is typically identified in the exotic species' native location as influential in reducing its unchecked growth. It is then thoroughly studied for any potential damage its introduction may pose. If it is found to be harmless, it is released in the problem areas. The Anacostia Watershed Society just started using weevils (a species of beetle) to control rapidly expanding populations of mile-a-minute (*Polygo-*

Volunteers remove weeds at Northwest Branch of the Anacostia River, College Park , MD.

Targeted Invasive Plant Species in the Anacostia River Watershed		
Species	Methods	Time of the Year
Beefsteak plant (*Perilla frutescens*)	HR/H	Summer
Bush honeysuckle (*Lonicera x spp.*)	HR/TR/H	Year-round
Chinese privet (*Ligustrum sinense*)	H/TR	Winter
Common periwinkle (*Vinca minor*)	TR/H	Winter/Year-round
English ivy (*Hedera helix*)	HR/TR/H	Winter/Year-round
Garlic mustard (*Alliaria petiolata*)	HD/H	Spring
Gill-over-the-ground (*Glechoma hederacea*)	HR/H	Winter
Japanese barberry (*Berberis thunbergii*)	TR	Year-round
Japanese honeysuckle (*Lonicera japonica*)	HR/H	Late Spring/Summer
Japanese knotweed (*Polygonum cuspidatum*)	H/TR	Year-round
Japanese stilt grass (*Microstegium vimineum*)	HR/H	Late Spring/Summer
Kudzu (*Pueraria lobata*)	H	Spring/Summer
Lesser celandine (*Ranunculus ficaria*)	TR/H	Late Winter
Mile-a-minute (*Polygonum perfoliatum*)	HR/H/Bio	Spring/Summer
Multiflora rose (*Rosa multiflora*)	TR/H	Year-round
Porcelain-berry (*Ampelopsis brevipedunculata*)	H	Spring/Summer
Purple deadnettle (*Lamium purpureum*)	HR	Spring/Summer
Purple loosestrife (*Lythrum salicaria*)	Bio	Spring/Summer
Tree-of-heaven (*Ailanthus altissima*)	HR/H	Year-round
Wavyleaf basketgrass (*Oplismenus hirtellus ssp. undulatifolius*)	HR/H	Spring/Summer
Wineberry (*Rubus phoenicolasius*)	TR	Year-round

HR: hand-removal; TR: hand-tool removal (with spading fork); H: herbicide application, Bio: biological control.

num perfoliatum) and will soon release shipments of another beetle species to control purple loosestrife (*Lythrum salicaria*) populations. The weevils (*Rhinoncomimus latipes*) were applied at a mile-a-minute patch in the Northwest Branch of the Anacostia River, contiguous to Magruder Park in the city of Hyattsville, Maryland.

Re-vegetation: Planting native trees, shrubs, and herbs is an integral method of erosion control after invasive plant removal. It is also one of the most commonly used habitat restoration methods in this program. The Anacostia Watershed Society works with nurseries to ensure that all the seedlings are native species of local provenance.

Target Invasive Species

Even though plant removal efforts target any exotic invasive species, the Anacostia Watershed Society has focused on the most prevalent and highly invasive species in the watershed.

RESULTS

As of April 2009, the Anacostia Watershed Society removed at least 21 invasive plant species from a total area of approximately 47.2 acres. These figures are estimates because acreage was not recorded for all species removed. The invasive plant removal was performed at 23 sites, the majority of which were public recreational parks in Maryland. Removal efforts help control the dispersion of harmful species that would otherwise affect sensitive and remnant urban natural areas if left unmanaged. This is particularly true for the control of species that are in their first stages of infestation either at a very local level or at the larger landscape level.

The use of site-based and weed-based approaches, combined with adaptive management, has been vital in addressing the abundant plant invasions throughout the watershed with limited resources. Additionally, the early detection/rapid response approach promptly controlled the outbreak of wavyleaf basket grass before it became widespread and out of control.

A site near the 38th Street Bridge, on the Northwest Branch of the Anacostia River near Hyattsville, has especially benefited from this program. As a consequence of levee construction in the 1950's, much of its natural channel morphology was

Volunteers plant native herbaceous plants in an experimental plot along the Northwest Branch of the Anacostia River in Hyattsville, Maryland.

Acreage of Invasive Plants Removed (2005-2009)	
Species	Area of Plants Removed (Acres)
Beefsteak plant (*Perilla frutescens*)	0.145
Bush honeysuckle (*Lonicera x spp.*)	6.02
Chinese privet (*Ligustrum sinense*)	1
Common periwinkle (*Vinca minor*)	0.8475
English ivy (*Hedera helix*)	4.73
Garlic mustard (*Alliaria petiolata*)	3
Gill-over-the-ground (*Glechoma hederacea*)	0.1
Japanese barberry (*Berberis thunbergii*)	0.22
Japanese honeysuckle (*Lonicera japonica*)	6.11
Japanese knotweed (*Polygonum cuspidatum*)	0.09
Japanese stilt grass (*Microstegium vimineum*)	9
Kudzu (*Pueraria lobata*)	0.5
Lesser celandine (*Ranunculus ficaria*)	0.6
Mile-a-minute (*Polygonum perfoliatum*)	1.49
Multiflora rose (*Rosa multiflora*)	6.09
Porcelain-berry (*Ampelopsis brevipedunculata*)	0.2
Purple deadnettle (*Lamium purpureum*)	0.09
Tree-of-heaven (*Ailanthus altissima*)	3.5
Wavyleaf basketgrass (*Oplismenus hirtellus ssp. undulatifolius*)	3
Wineberry (*Rubus phoenicolasius*)	0.4638
	Total: 47.20

replaced with large, angular blocks of gray granite (rip-rap). The Anacostia Watershed Society conducted an experimental native re-vegetation project on the rip-rap slope at the river bank in order to demonstrate an alternative to the county's annual mowing-and-spraying of herbicide, and to also restore a native open-land ecosystem that is disappearing rapidly in Maryland.

In 2007, more than 9,080 individual plants of 27 locally native species were planted at the Hyattsville site. Preliminary results and observations show that the plot cultivated with native herbaceous species along the rip-rap slopes of the river support more plant species diversity (80 plant species) and wildlife than those that are subject to the mowing-and-spraying method (43 plant species found at the end of the survey). These native plantings provide the added benefit of improving the park landscape and providing a continuum of open-land habitat for wildlife along the riverbanks.

KEYS TO SUCCESS

- **Involve the public** and engage enthusiastic volunteers, such as school groups, church groups, and interns.
- **Link invasive plant species control with public environmental education** to increase awareness of the problem.
- **Use an adaptive management approach** and be flexible with the proposed control methods.
- **Use the early detection/rapid response approach** to avoid further serious invasive plant invasions that threaten to become costly.
- **Support your actions with scientific criteria**, even if the project is an on-the-ground stewardship effort.
- **Secure stable and long-term financial resources** because invasive plant species control is a long-term conservation project.

PHOTOS AND FIGURES

All photos and figures by the Anacostia Watershed Society except page 264, Burke Environmental Associates/The Conservation Fund

REFERENCES

[1]International Union for Conservation of Nature. 2000. *IUCN Guidelines for the Prevention of Biodiversity Loss caused by Alien Invasive Species*. Fifth Meeting of the Conference of the Parties to the Convention on Biological Diversity, Nairobi, Kenya, 15-26 May, 2000. 21 pp. Available online at: http://www.cites.org/eng/com/AC/16/Inf16-10.pdf.

[2]Swearingen, J., K. Reshetiloff, B. Sattery and S. Zwicker. 2002. *Plant Invaders of Mid-Atlantic Natural Areas*. Report by the National Park Service, and U.S. Fish and Wildlife Service. Washington, D.C. 82 pp. Available online at: http://www.nps.gov/plants/alien/pubs/midatlantic/.

[3]National Invasive Species Council. 2003. *General Guidelines for the Establishment and Evaluation of Invasive Species Early Detection and Rapid Response Systems*. U.S. Department of Interior, Washington, D.C. 18 pp. Available online at: http://invasivespecies.nbii.gov/documents/inv_NISCEDRRGuidelineCommunication.pdf.

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ANACOSTIA WATERSHED SOCIETY

Effective Techniques for Invasive Plant Control and Wildlife Habitat Restoration

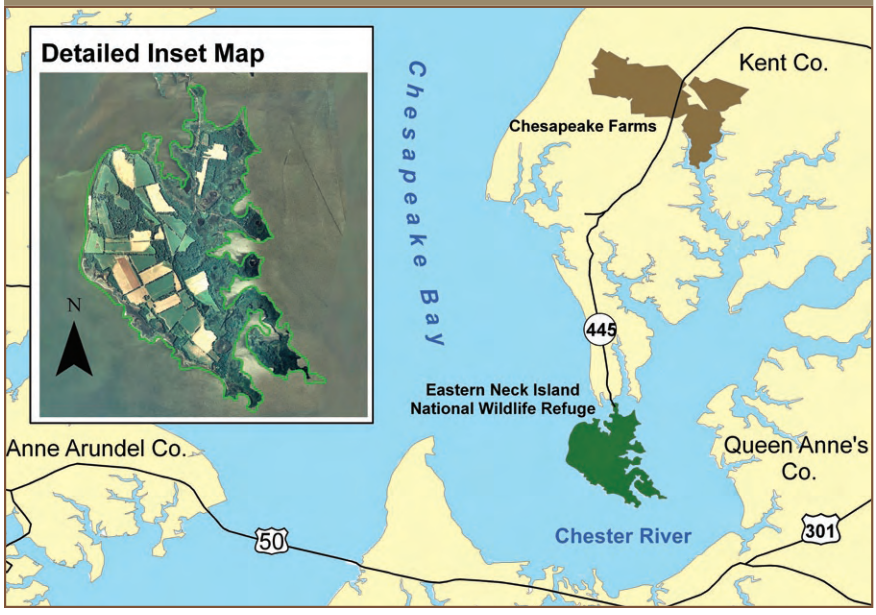
Integrated Vegetation Management at Eastern Neck National Wildlife Refuge

With over 60% of the Eastern Neck National Wildlife Refuge infested by invasive exotic plant species, the Refuge and IVM Partners initiated an integrated vegetation management plan that successfully reclaimed more than 147 acres of Refuge habitat.

CASE STUDY SUMMARY

Improvements to invasive species management in the Chesapeake Bay region are vital to biodiversity conservation and ecosystem restoration. In an effort to find new and more effective ways to remove exotic invasive plants, Integrated Vegetation Management Partners, Inc. (IVM Partners), a 501(c)(3) nonprofit corporation, researched, developed and carried out an integrated vegetation management plan for the Eastern Neck National Wildlife Refuge. As a result, IVM Partners restored 100 acres of wetlands at the Refuge that were previously dominated by the invasive common reed (*Phragmites australis*) (hereafter referred to as *Phragmites*), and 47.6 acres of forest habitat, allowing native plants and animals to return.

Eastern Neck Island National Wildlife Refuge Location Map



Eastern Neck National Wildlife Refuge is situated on a 2,285 acre island at the confluence of the Chester River and Chesapeake Bay in Kent County on Maryland's Eastern Shore. The island supports over 100,000 migrating ducks, geese and swans, as well as songbirds, shorebirds and resident bald eagles. The Refuge, as with other refuges managed by the United States Fish and Wildlife Service (U.S. Fish and Wildlife), was created to protect the lands and waters needed to conserve the region's fish, wildlife and plants. With 6 miles of roads and trails, as well as boat ramps, the Refuge provides year-round access to citizens for viewing, fishing and hunting its abundant wildlife. The road and water access also brings unwelcome visitors to the Refuge; namely exotic invasive plants, which threaten the Refuge's unique biodiversity and critical habitats.

In 2004, IVM Partners conducted research at Chesapeake Farms, a private agricultural and wildlife research

The forest floor of the Eastern National Wildlife Refuge covered by invasive exotic plant species.

center owned by the DuPont Corporation near the Refuge, to determine the best available integrated vegetation management techniques, which reduce the need for herbicides, promote healthy ecosystems and provide measurable results, such as greater natural species diversity and better control of invasive species. These techniques may include chemical removal, physical (or mechanical) removal, biological control, and prescribed burning. In 2006, IVM was hired by the Eastern Neck National Wildlife Refuge to identify the highest priority habitats at the Refuge, develop a management plan, treat at least 75 acres using a combination of techniques, and monitor the managed areas to evaluate the results.

RESOURCE MANAGEMENT CHALLENGE

Biologists estimate that invasive plants occupy approximately 60% of the Refuge's 2,285 acres. These invasive species destroy natural habitat and result in the local extirpation of native species of plants and the animals that depend upon them. Invasive species are directly responsible for approximately 42% of the species on the federal threatened or endangered species lists.[1] The loss of native species can negatively impact ecological processes and wildlife recreation activities, thereby threatening the original purpose of the Refuge.

The Refuge has confirmed the presence of the following invasive on the island: mile-a-minute (*Polygonum perfoliatum*), Japanese honeysuckle (*Lonicera Japonica*), wineberry (*Rubus phoenicolasius*), multiflora rose (*Rosa multiflora*), Japanese stilt-grass (*Microstegium vimineum*), autumn olive (*Cirsium arvense*), princess tree (*Paulownia tomentosa*), tree-of-heaven (*Ailanthus altissima*), Chinese lespedeza (*Lespedeza cuneata*), english ivy (*Hedera helix*), garlic mustard (*Alliaria petiolata*), Johnson grass (*Sorghum halepense*), Canada thistle (*Cirsium arvense*) and *Phragmites*.

Invasive species cause major environmental and economic damage with national loses adding up to $120 billion per year.[2] Although invasive exotic species control is often a priority for conservation management, the methods can be controversial[3] and may have detrimental impacts on non-target species.[4] With invasive exotic plants in particular, herbicides have proven to be effective at reducing the number of targeted plants, but their safe and effective use requires certification training and equipment designed for the task. With more than 200 exotic plant species in the Mid-Atlantic region of the United States, it is imperative that the conservation community devise methods that are safe, reliable, economic and effective at controlling these species.

CONSERVATION VISION

The Refuge staff was aware of the invasive species problem on Eastern Neck Island, but didn't have the expertise to address it. After seeing IVM Partners' research at Chesapeake Farms, U.S. Fish and Wildlife contracted with them in 2006 to: conduct a site assessment; develop a management plan outlining the areas to be treated, their management and monitoring methods, and any public safety concerns; chemically treat at least 75 acres (mapped and prioritized by Refuge staff) and achieve an 80% efficacy of target plants; monitor management sites; and abide by a series of other safety and coordination agreements.

IMPLEMENTATION RESOURCES

In 2004, IVM Partners was awarded a $75,000 grant from National Fish & Wildlife Foundation to apply and study integrated vegetation management techniques on electric rights-of-way within the Pinelands of Southern New Jersey and expand their education efforts on a national level. The DuPont Corporation, which provided some matching funds

for the Pinelands grant, offered its wildlife and agricultural research acreage at Chesapeake Farms, near the Refuge, to IVM Partners as an area for conducting vegetation management research for utility and highway rights-of-way.

In 2006 and 2007, U.S. Fish and Wildlife allocated $128,000 to contract with IVM Partners for treatment research and botanical documentation of 95 acres at the Refuge. IVM Partners reviewed the proposed treatment areas with three applicator subcontractors and awarded the work to Weeds, Inc., on a time and material basis, while Davey Resource Group provided GIS mapping in-kind services and Chesapeake Wildlife Heritage provided consistent botanical documentation.

Since the work varied from easily accessible roadside brush, to impenetrable wooded sites and dense stands of *Phragmites*, the application costs varied from $100 to $1,000 per acre. Due to the chemical resistance of some target plants, some sites required multiple herbicide treatments, which were applied in successive years and with different types of herbicides. U.S. Fish and Wildlife provided the manpower and equipment for required mowing, guidance for management priority sites, expertise for conducting controlled burns and assistance in geographical information system (GIS) mapping and workshop hosting.

CONSERVATION STRATEGY

Invasive Species Control Techniques: There are four general techniques used to control invasive plant species in the Chesapeake Bay region: chemical removal, physical (or mechanical) removal, biological control, and prescribed burning.

The following descriptions were derived from U.S. Fish and Wildlife's website on invasive species management.[5]

- ***Chemical methods*** use herbicides to suppress or kill unwanted plants and are the primary methods used by managers to control invasive plants. These methods require judicious and safe applications, so as not to affect water quality and non-target organisms. Herbicides are classified and chosen according to the following criteria: chemical structure, mode of action (systemic or contact), site of uptake (roots, shoots or leaves), site of action (location of biochemical process), mechanism of action (biochemical process affected), persistence, selectivity and application timing (pre-emergence or post-emergence).
- ***Physical methods*** are used to remove, kill, injure or alter growing conditions for unwanted plants. These methods allow managers to be highly selective with minimal environmental impact, but tend to be expensive and labor intensive. These methods include: pulling, hoeing, tilling, mowing, cutting, stabbing, girding, chaining, mulching, flooding, harvesting, and dredging.
- ***Biological control*** uses the natural enemies of invasive plants to control their populations. This method is used to suppress an infestation where other methods are not economically feasible. It requires careful preliminary work to insure that there are no unintended consequences of releasing another exotic species.
- ***Prescribed burning*** can mimic natural disturbance conditions in ecosystems. This method is widely used for habitat restoration, and under ideal conditions it can also be used to suppress and control populations of invasive plant.

IVM Partners demonstrate the use of herbicides as a part of an integrated vegetation management strategy to control invasive plants at Chesapeake Farms.

Integrated Vegetation Management: Integrated vegetation management allows for the pairing of various techniques that, when used together, can be more effective at eliminating invasive species from a site. Physical methods, such as annual mowing, are often used to maintain warm season prairie grass, but if one looks closely under the grass they may find a mixture of invasive weeds that are simply being cropped close to the ground. Prescribed burning is also

Integrated Vegetation Management Techniques		
Target	Control Technique	Detailed Method
Invasive trees	Physical and chemical	Girdling and basal herbicide, or foliar herbicide to actively growing leaves.
Invasive shrubs	Physical and chemical	Mowing immediately followed by basal herbicide or foliar herbicide during next growing season.
Perennial woody invasives	Chemical and burn	Foliar herbicides during growing season, followed by a burn during dormant season.
Annual herbaceous invasives	Chemical and burn	Post emergent herbicide treatment during growing season and before seed production, or pre-emergent herbicides to prevent germination, followed by a burn during dormant season.
Phragmites	Physical, chemical and burn	Foliar herbicides during the growing season followed by a burn, mow or mulch during dormant season.

used for grass maintenance but does not always remove target invasive plants, since controlled burns seldom kill plant roots. If chemical methods are used, a periodic broadcast application may be relied on to wipe out the invasive infestation, only to have the remnant plants reinvade a few years later. At the Refuge, IVM Partners worked to implement a truly integrated strategy that paired methods to more effectively control invasive species.

IVM Partners initial research began in 2004 at Chesapeake Farms, where they experimented with different integrated vegetation management techniques to address management concerns of electric utility companies that maintain rights-of-way across public lands, and the government agencies that manage surrounding lands. In 2005, IVM Partners and Chesapeake Farms held a workshop at the farm to demonstrate their results and learn from others in the field of vegetation management. The workshop showed how best to control invasive trees (tree-of-heaven), invasive shrubs (autumn olive, multiflora rose), perennial woody invasives (Japanese honeysuckle, wineberry), annual herbaceous invasives (Japanese stiltgrass, mile-a-minute, Chinese lespedeza), and *Phragmites*. Demonstrations were also conducted to show how to regenerate native prairie grasses through the release of dormant seed banks in the soil which can grow once rapidly spreading sweetgum (*liquidambar styraciflua*) trees and invasive shrubs are controlled.

After the workshop, IVM Partners was asked to visit the Refuge to discuss management options for controlling invasive plants and restoring wildlife habitat. IVM Partners determined the density and number of invasive plants found on the Refuge would require substantial treatment and that the Refuge's standard control technique, of staff using backpacks to apply herbicide treatments, would be futile. With numerous invasive species reproducing across 60% of the Refuge, it was clear that they needed a professional partner and an innovative strategy.

IVM Partners entered into a contract with U.S. Fish and Wildlife to serve as a general contractor and coordinator of the integrated vegetation management effort at the Refuge. Their work involved: the drafting of the vegetation management plan; GIS mapping of treatment sites; contracting with Weeds Inc., a certified pesticide applicator company; development of herbicide mixes and application techniques prescribed to each invasive plant(s) and specific to forest floor, roadsides, agricultural fields or wetlands; and botanical and photo documentation of selected treatment sites.

Due to the extent of invasive species infestation and access difficulty, IVM Partners directed initial applications to the invasive plants that had the most deleterious impact to Refuge habitat and in locations 50-feet deep into the woods along targeted roadsides, trails, wetlands and agricultural field edges, with control areas left for comparison. If this proved successful on the initial application, then subsequent applications could be directed deeper into the forest. The benefit of having treatments along easily observed roads and trails is that it provided both Refuge staff and the visiting public with tangible examples of success at habitat reclamation.

The location of the Refuge at the confluence of the Chester River and Chesapeake Bay placed waterfowl habitat at the top of the priority list. This in turn placed control of Phragmites at the top of the vegetation management priority list, as control of this aggressive plant would allow restoration of native wetland plants, a crucial food source for migrating waterfowl of the Atlantic flyway.

In addition to the waterfowl habitat and the 50-foot deep treatments, Refuge biologists wanted to reclaim several wooded blocks from invasive infestations and see if native vegetation could return. To successfully treat these areas, mowing was needed to cut access lanes into the jungle-like growth of invasive plants. The contracted crews could then use the mowed lanes for spray vehicle access and broadcast treat the forest floor vegetation with herbicides applied through hydraulic hoses. Hydraulic applications are very similar to spraying water with a garden hose, only the water contains herbicides that will target the invasive plants. Blue dye is added to the water as a marker to note area treatment coverage.

In August and October of 2006, treatment areas, including wetlands, forests, fields, trails, and roads each had target species and were treated with a particular control technique. Certain techniques, such as combining the use of herbicides and physical removal, have proven to be more effective at killing the target species. In addition to mowing and spraying with a combination of herbicides, the Refuge vegetation management plan also called for controlled burning during the dormant season following a broadcast herbicide treatment. Chesapeake Wildlife Heritage established permanent transects to monitor plant community changes in the fields on the north and south ends of the Refuge.

Successful control of invasive plants invariably requires a follow-up herbicide treatment the following growing season, with periodic treatments as warranted by inspections. If a few stems of an invasive plant are allowed to exist, in a very short time they will out-produce the native plants and again dominate the site. Landscaping with native plants is seldom necessary as their seeds are normally still viable and will germinate once the invasive plants, and their corresponding allelopathic chemicals, have dissipated.

RESULTS

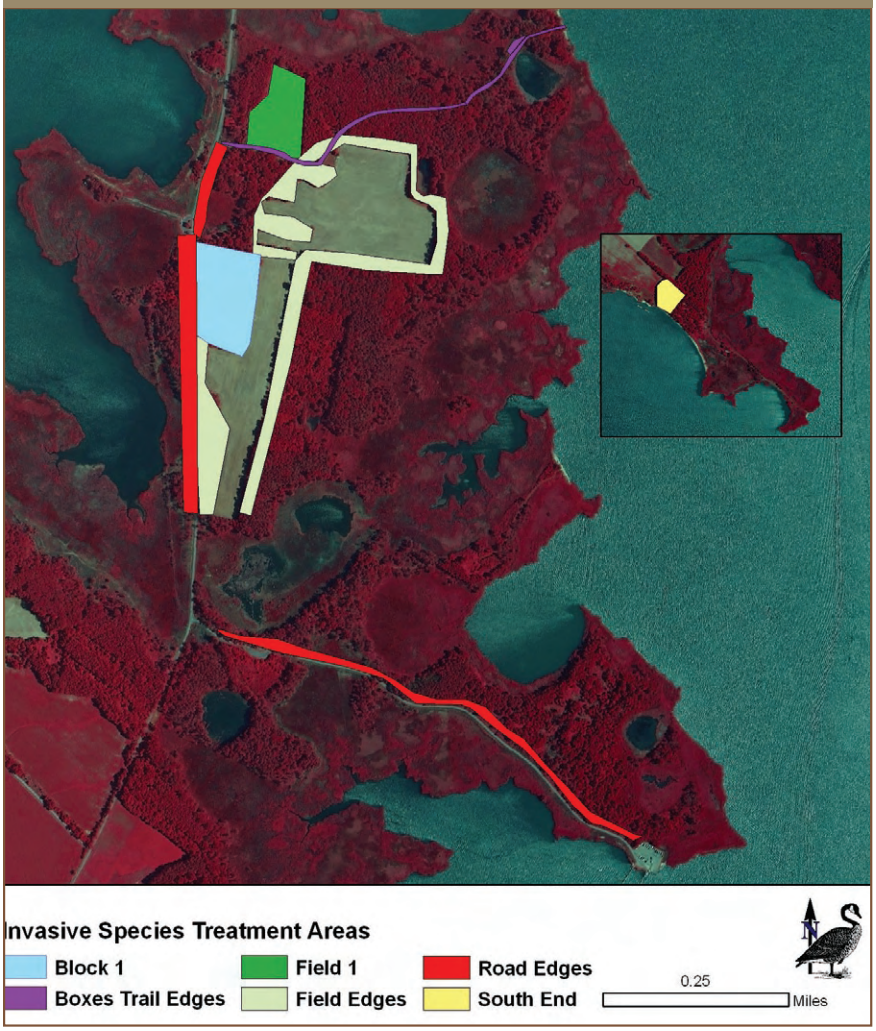
At Eastern Neck National Wildlife Refuge, the combination of the efficiency

Defeating *Phragmites australis*

Phragmites is a perennial grass that primarily spreads by rhizome roots and can advance rapidly through all types of growing material. Although the species is native, scientists believe that an aggressive non-native genotype was introduced to North America.[6] Once established, *Phragmites* develops into a monoculture of dense stems that crowd-out native plants by blocking sunlight, consuming nutrients, and exuding allelopathic chemicals, particularly gallic acid that turns into mesoxalic acid when degraded by the sun's ultraviolet rays, which attacks the proteins in the roots of competing plants.[7]

To successfully defeat *Phragmites*, one must not only kill the roots of the plant using herbicides, but also remove the dead plant material from the site, especially if it has built up a thick thatch layer over the years. In 2005, IVM Partners and Chesapeake Farms applied Habitat (imazapyr) and Accord (glyphosate) herbicides with surfactant to an area of *Phragmites* using a hydraulic sprayer. The phragmites debris was then removed with a controlled burn in the winter of 2006. A selective backpack application using the same herbicides was performed the summer of 2006 to the few remnant live stems of *Phragmites*. The result was a release of 36 native wetland plant species whose seeds were lying dormant just waiting for the chance to germinate.

Eastern Neck National Wildlife Refuge
*Rock Hall, Maryland**



**Map does not include information about wetland control efforts.*

of the application crews, and cooperative mowing access by Refuge staff, resulted in the treatment of a total of 146.7 acres in 2006, nearly twice as much acreage as the IVM Partners contract required. Approximately 100 acres of *Phragmites*-dominated wetlands were successfully controlled. In addition, approximately 47.6 acres of forested areas were treated to remove several species of invasive plants.

Native plants regenerated on their own at the treatment sites after controlling the invasive weeds. Sites formerly dominated by *Phragmites* now have native wetland plants, which have attracted native birds and mammals back to the Refuge. Wooded sites formerly overrun with invasive plants that were mowed and treated with herbicides, now have naturally regenerating loblolly pines (*Pinus taeda*) at a density of 3 per square meter.

IVM Partners and the Refuge determined that controlling invasive species across the Refuge is a high priority and a major challenge requiring significant funding and time. This conclusion led the Refuge staff to initiate the revision of their Comprehensive Conservation Plan for the Refuge, which will update management priorities to include use of integrated vegetation management techniques to control invasive species.

Control of the invasive plants was only part of the project's results. The project allowed IVM Partners and the Refuge to learn more about best management practices for restoring critical habitat from invasive weed infestation and share the results with others. The Refuge now functions as an outdoor classroom for vegetation management education and innovation. Refuge treatment sites continue to be a major educational centerpiece for workshops and presentations that have included participants from numerous federal agencies, corporations and nonprofit conservation organizations.

Lastly, the integrated vegetation management workshop in 2005 helped convince federal land management agencies and Edison Electric Institute to sign a memorandum of understanding to adopt integrated vegetation management as the preferred management process for all electric rights-of-way crossing federally managed lands.

KEYS TO SUCCESS

A truly integrated approach: To successfully control non-native invasive plants one must use an integration of control techniques, including: chemical, physical, biological, or prescribed burning. At the Refuge this included mowing, fire, and a combination of judicious herbicide applications. The choice of control technique(s) is based on effectiveness, environmental impact, site characteristics, worker and public health and safety concerns, security and economics.

Multiple types of herbicides: The Refuge learned not to rely solely on one type of herbicide for management. Rodeo (glyphosate) was previously the chemical of choice for

Eastern Neck National Wildlife Refuge Upland Treatment Areas, Targets and Applications		
Location	Species Targets	Applications
Forest Block 1	Mile-a-minute, Japanese honeysuckle, multi-flora rose, autumn olive, wineberry, and Japanese stiltgrass.	Geoboy to mow access lanes; Garlon 3A (triclopyr), Escort (metsulfuron) Roundup (glyphosate), Plateau (imazapic) and Aquacap (pendimethalin)
Field 1	Sweet gum suppressing growth of native loblolly pine and other invasive plants.	Oust Extra (sulfometuron and metsulfuron)
Road Edges & Trail Edges	Mile-a-minute, Japanese honeysuckle, multiflora rose, autumn olive, wineberry, Japanese stiltgrass and *Phragmites*.	Habitat (imazapyr) and/or Rodeo (glyphosate), controlled burn
Field Edges	Sweet gum, mile-a-minute, Japanese honeysuckle, multiflora rose, autumn olive, wineberry, and Japanese stiltgrass.	Garlon 3A (triclopyr) and Escort (metsulfuron)
South End	Mile-a-minute, Japanese honeysuckle, wineberry, multiflora rose and Japanese stiltgrass	Oust Extra (sulfometuron and metsulfuron), Plateau (imazapic) and Aquacap (pendimethalin)

all *Phragmites* treatments by Refuge staff, but this can damage loblolly pine trees. In addition, glyphosate is an amino acid inhibitor and can be much more effective when combined with another amino acid inhibitor, Habitat (imazapyr). Imazapyr also offers flexibility in treatment methods when attacking *Phragmites* over open marshland that is not easily accessed from ground vehicles. Plateau (imazapic) and Aquacap (pendimethalin) were used effectively in some locations to prevent germination of mile-a-minute and Japanese stiltgrass.

Partnership between stakeholders: In many circumstances the relationship between industry, conservation and public agencies can be adversarial instead of cooperative. This project was successful because a non-profit corporation acted as a liaison between chemical manufacturers, applicators, U.S. Fish and Wildlife, and other groups to provide a forum for learning and applying the best IVM techniques for habitat restoration.

Bogles Wharf at Eastern Neck National Wildlife Refuge, formerly infested with phragmites, was treated by IVM Partners in 2008 and has since recovered with native species.

An adaptive management approach: The project succeeded by learning from mistakes, adapting to changing situations, and being willing to try multiple approaches instead of entering into the process with preconceived ideas of what was right and wrong. U.S. Fish and Wildlife solicited comments from wildlife experts to define management objectives; they allowed professional contractors to conduct the initial herbicide treatments; pesticide use permits were obtained for using several herbicide products; and third party botanical and photo documentation provided unbiased assessment of successful techniques. The parties were also committed to a multi-year process to monitor how plant communities changed over time.

Forest floor at Eastern Neck National Wildlife Refuge showing Japanese stiltgrass infestation (left) and treated area (right).

An actively engaged public: U.S. Fish and Wildlife took special steps to involve and inform the public, and was rewarded with a standing ovation at a community meeting for having restored native plant communities not seen for many years.

PHOTOS AND FIGURES

Page 271: Photo, IVM Partners; figure, Burke Environmental Associates/ The Conservation Fund, using Google Earth image
Page 272: Photo, USFWS, Eastern Neck National Wildlife Refuge
Page 273, 277, 278: Photos, IVM Partners
Page 275: Photo, Chesapeake Bay Foundation/cbf.org
Page 276: Figure, USFWS, Eastern Neck National Wildlife Refuge

REFERENCES

[1,2]Pimentel, D., R. Zuniga and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics*. 52(3):273-288.

[3]Collins, S. 2009. Killing of Mute Swans in Maryland Causes Controversy. *WJZ13* (June 9, 2009). Available online at: http://wjz.com/local/mute.swans.2.1037766.html. (Accessed 2010).

[4]Bergstrom, D. M., A. Lucieer, K. Kiefer, J. Wasley , L. Belbin, T. Pedersen and S. L. Chown. 2009. Indirect effects of invasive species removal devastate World Heritage Island. *Journal of Applied Ecology*. 46(1):73-81.

[5]United States Fish and Wildlife Service. 2009. Managing invasive plants: Concepts, principles and practices. United States Fish and Wildlife Service, National Wildlife Refuge System. In, http://www.fws.gov/invasives/staffTrainingModule/index.html. (Accessed 2010).

[6]Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the common reed, Phragmites australis, into North America. *Proceedings of the National Academy of Sciences*. 99(4):2445-2449.

[7]Rudrappa, T., Y. S. Choi, D.F. Levia, D. R. Legates, K. H. Lee and H. P. Bais. 2009. *Phragmites australis* root secreted phytotoxin undergoes photo-degradation to execute severe phytotoxicity. *Plant Signaling and Behavior*. 4(6):506-513.

FOR MORE INFORMATION

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Integrated vegetation management and ecosystem management studies and workshops are proposed for various regions of the country to determine the best integrated vegetation management practices necessary for restoration of ecosystems unique to these geographic areas. Dates for workshops and summaries of photo and botanical documentation of these projects are available online at: www.ivmpartners.org.