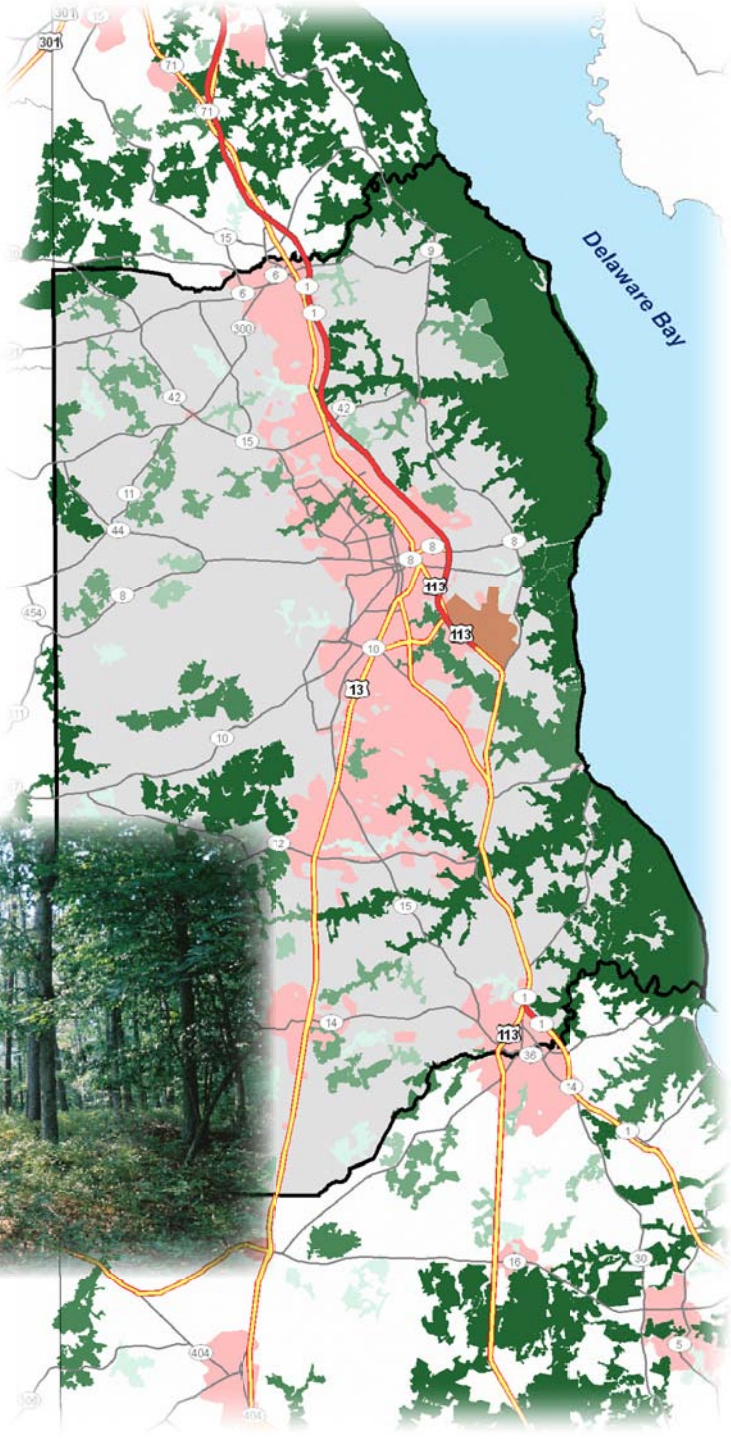
Kent County, Delaware

Rapid Assessment of Green Infrastructure

June 2006



Kent County, Delaware

Rapid Assessment of Green Infrastructure

A publication of The Conservation Fund

The Conservation Fund forges partnerships to conserve America's legacy of land and water resources. Through land acquisition, sustainable programs, and leadership training, the Fund and its partners demonstrate balanced conservation solutions that emphasize the integration of economic and environmental goals. Since 1985 The Conservation Fund and its partners have permanently protected more than 5.4 million acres of important wildlife habitat, working landscapes, and recreation areas. (http://www.conservationfund.org, http://www.greeninfrastructure.net)

William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund — NC Office
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
wallen@conservationfund.org

Blaine T. Phillips, Jr.
Mid-Atlantic Regional Director
The Conservation Fund — DE Office
5807 Kennett Pike
Centreville, DE 19807
302-656-1103
bphillips@conservationfund.org

table of contents

list of maps

Kent County Rapid Assessment of Green Infrastructure

Assessment SUMMARY

The Conservation Fund has completed a rapid assessment of green infrastructure assets in Kent County, Delaware. Based on the approach outlined in *Green Infrastructure: Linking Landscapes and Communities* (Benedict and McMahon, 2006), the Fund has undertaken an ambitious series of tasks intended to help identify and prioritize the County's green infrastructure network. A thorough review of current state planning initiatives was completed as a key input into the assessment approach (see box on opposite page). Based on this review, the Fund determined that the best course of action would be to focus on identifying locations where *Livable Delaware* goals could be achieved based on the planning principles outlined in *Better Models for Development in Delaware* and *State Strategies for Policy and Spending*.

Using the green infrastructure approach to strategic conservation, the rapid assessment focused on three key steps for successful green infrastructure planning efforts: creating a network design, convening a leadership forum, and developing an implementation quilt. The network design encompasses the full interconnected network of green infrastructure, including natural areas, green space, and working landscapes. The network design step included the delineation of a statewide **Delaware Ecological Network (DEN)**, the preparation of a protected lands inventory and a working landscapes inventory, and an historic evaluation of the State's purchase of development rights program for agricultural lands. These three key network design inputs will help Kent County measure progress towards the *Livable Delaware* goals for productive cropland, commercially viable forestland, and conservation and recreation priorities.

Following the delineation of the DEN and the completion of the inventories, the Fund convened a **Green Infrastructure Leadership Forum** consisting of over 20 public and private conservation partners in October 2005. The Forum provided the necessary input to perform the GIS-based green infrastructure suitability analysis and land parcel scoring for ecological systems, working landscapes, and *Better Models* protection sites. Suitability models and parcel rankings for working farms, working forests, and natural resources were then developed using data inputs including core green infrastructure network elements from the DEN, the *Livable Delaware* Green Infrastructure Map, proximity to existing protected lands, and the Land Evaluation / Site Assessment (LESA) parcel scoring system developed by the Delaware Agricultural Land Preservation Foundation (DALPF).

The final step was the development of an **Implementation Quilt** that provided recommendations regarding potential implementation tools and, where appropriate, matched them to specific components of the network design. The Implementation Quilt's policy and funding recommendations, which were based on the findings from the network design and the leadership forum, will help achieve the *Livable Delaware* goals. The

recommendations include guidance on where State funding and policy can be directed to achieve the most beneficial and cost effective strategies for ecological and working landscape protection. The recommendations also provide guidance to local governments and nonprofits on how to best leverage their available planning tools.

To facilitate future planning and implementation efforts, the Fund's Strategic Conservation Program has developed a GIS-based decision support tool to help the Fund and its partners to proactively identify new land conservation opportunities and evaluate related protection projects as they arise.

Delaware Statewide Planning Efforts

Livable Delaware

Livable Delaware is the state's strategy to combat land consumptive sprawl by directing well-designed growth to areas where the state, county, and local governments have planned for new development. Its key goals are:

- Preserve half of Delaware's remaining, unpreserved cropland by 2024.
- Preserve half of Delaware's remaining, unpreserved commercially viable forest by 2024.
- Preserve 100% of Delaware's remaining natural resource and recreation priorities.

Under the leadership of Governor Ruth Ann Minner, *Livable Delaware* uses five principles to determine where Delaware should grow:

1. Guide growth to areas most prepared to accept it in terms of infrastructure and thoughtful planning
2. Preserve farmland and open space
3. Promote infill and redevelopment
4. Facilitate attractive, affordable housing
5. Protect quality of life while slowing sprawl

Livable Delaware is an effort to align state spending with local land use decisions. Local governments are required to identify future growth areas and provide a detailed plan of services within their comprehensive plan, which serves as a guide for any annexation. The state directs its agency spending to designated growth areas, providing assistance to local governments where they most need it.

Strategies for State Policies and Spending

The *Strategies for State Policies and Spending* promotes different types of investments appropriate to the prevalent and planned development patterns. It does this by matching the types of investments to four different levels of development intensity, ranging from urbanized areas with higher density, infrastructure, and services to predominantly agricultural land, natural resources, or areas with significant environmental constraints or concerns. The *Strategies* do not indicate priority but instead guide state spending decisions in line with the existing or planned built and natural environment.

Better Models for Development in Delaware

The Conservation Fund worked with the Governor, her *Livable Delaware* Advisory Council, and the Office of State Planning Coordination to create a guide for Delaware's local governments and developers as they make decisions about the patterns and characteristics of their communities' future growth. *Better Models for Development in Delaware* provides advice on how to implement community design decisions and realize *Livable Delaware* goals. It focuses on key issues facing communities throughout Delaware, such as: how to protect the countryside, how to strengthen downtowns, and how to improve the suburbs. With numerous photos and illustrations, *Better Models* provides examples of how key development principles and ideas can be applied to Delaware and elsewhere. *Better Models* begins with the premise that the most important model of development is first assessing where development should not take place and ensuring the protection of areas that are critical for the maintenance of the community's natural resources, wildlife habitat, working lands, scenic landscapes, and cultural and historic resources.

network design

The Delaware Ecological Network

In an effort to plan for green infrastructure protection before development takes place, the Fund designed the Delaware Ecological Network (DEN), a series of statewide geographic information system (GIS) layers that identify and prioritize the areas of greatest ecological importance within the State's natural ecosystems (see map on opposite page). The DEN, which is based on the principles of landscape ecology and conservation biology, provides a scientifically defensible framework for green infrastructure protection statewide.

Definition of Green Infrastructure

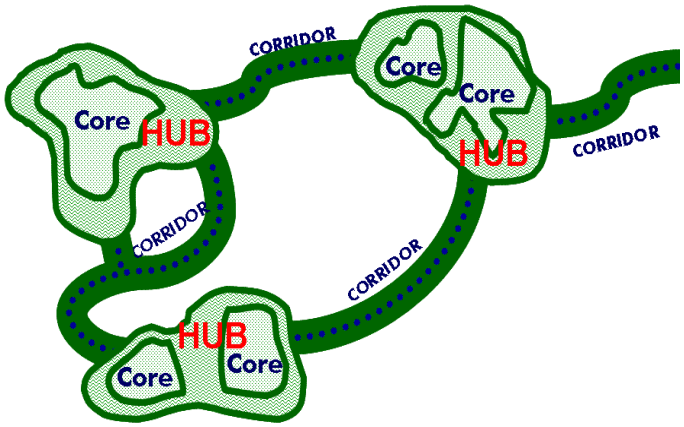
An interconnected network of natural areas (waterways, wetlands, and forests), green space (parks, greenways, and conservation lands), and working landscapes (farms, ranches, and woodlands) that protect natural ecological processes, support wildlife and benefit people.

For more information, please see http://www.greeninfrastructure.net

The DEN estimates that Kent County's natural areas encompass approximately 130,000 acres of core areas, hubs, and corridors, about 34% of the land area. As depicted here conceptually, the DEN consists of core areas, hubs and corridors. Core areas contain fully functional natural ecosystems, and provide high-quality habitat for native plants and animals. Core forest, wetland, and aquatic systems, which contain relatively undisturbed, mature forest, wetlands, and streams, comprise the majority of the ecological network in Kent County. Hubs are slightly fragmented aggregations of core areas, plus contiguous natural cover, while corridors link core areas together, allowing wildlife movement and seed and pollen transfer between them.

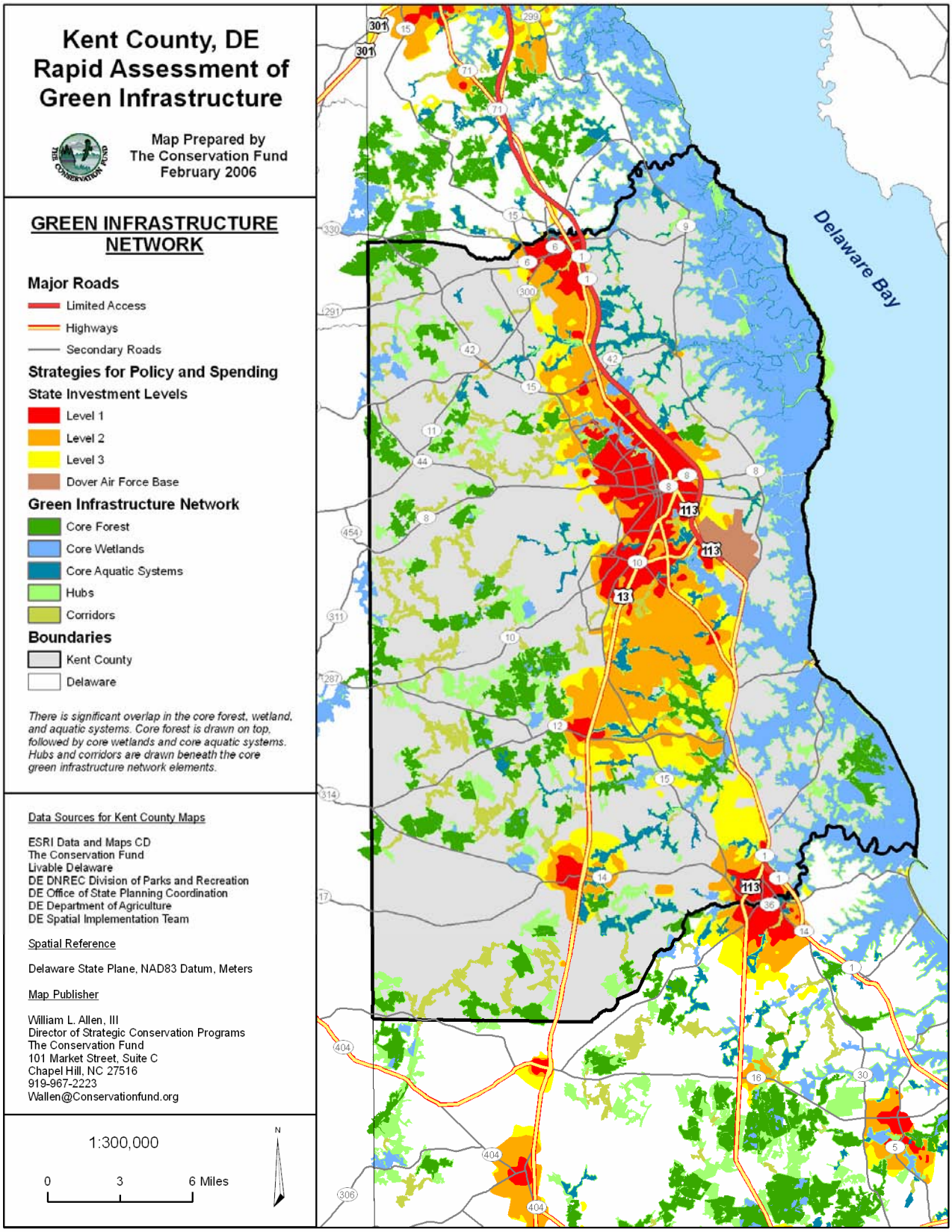
Approximately 63% of Kent County's natural systems are already in some form of protected status with only about 48,400 acres classified as unprotected. The table, right, outlines the distribution of unprotected lands.

Conceptual Model of the Delaware Ecological Network



NETWORK FEATURE	ACRES (nearest hundred)
Core Wetland and Aquatic Systems	22,600
Core Forest Systems	16,100
Working Lands Outside an Agricultural District*	5,600
Working Lands Inside an Agricultural District*	4,100
Total – Unprotected Network Lands	48,400

* Working lands within the DEN are mostly forested areas that lie within hubs and corridors that buffer core habitat areas.


Kent County, DE
Rapid Assessment of Green Infrastructure
Map Prepared by
The Conservation Fund
February 2006
GREEN INFRASTRUCTURE NETWORK
Major Roads
Limited Access
Highways
Secondary Roads
Strategies for Policy and Spending
State Investment Levels
Level 1
Level 2
Level 3
Dover Air Force Base
Green Infrastructure Network
Core Forest
Core Wetlands
Core Aquatic Systems
Hubs
Corridors
Boundaries
Kent County
Delaware
There is significant overlap in the core forest, wetland, and aquatic systems. Core forest is drawn on top, followed by core wetlands and core aquatic systems. Hubs and corridors are drawn beneath the core green infrastructure network elements.
Data Sources for Kent County Maps
ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team
Spatial Reference
Delaware State Plane, NAD83 Datum, Meters
Map Publisher
William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org
1:300,000
0
3
6 Miles
N
Delaware Bay

Protected Lands Inventory

Kent County's protected lands encompass approximately 115,400 acres (see map on opposite page), ranging from lands within the National Estuarine River Reserve System and State Fish and Wildlife Areas to agricultural easements purchased by the Delaware Agricultural Lands Preservation Foundation (DALPF). Many of Kent County's protected lands have been protected by Delaware's Open Space Program (see box below). About 75,400 acres fall within the DEN, while the remaining 40,000 acres are primarily in agricultural land use and other protected status outside the DEN that contain other significant natural, recreational, cultural, and/or historical resources.

Selected Protected Lands in Kent County

Bombay Hook National Wildlife Refuge ~ US Fish and Wildlife Service
Delaware National Estuarine Reserve ~ Blackbird Creek and St. Jones Reserve
Taber State Forest ~ Delaware Forest Service
Killens Pond State Park ~ Delaware State Parks

State Fish and Wildlife Areas

Blackiston, Blairs Pond, Bowers Beach, Coursey Pond, Derby Pond, Garrisons Lake, Griffith Lake, Haven Lake, Little Creek, McGinnis Pond, Milford Neck, Moores Lake, Mud Mill, Norman G. Wilder, Port Mahon, Ted Harvey, Woodland Beach

State Historical and Cultural Affairs Sites

Belmont Hall, John Dickinson Plantation, Octagonal School House

Private conservation lands and easements owned by

The Nature Conservancy, Delaware Wildlands, and other nonprofits

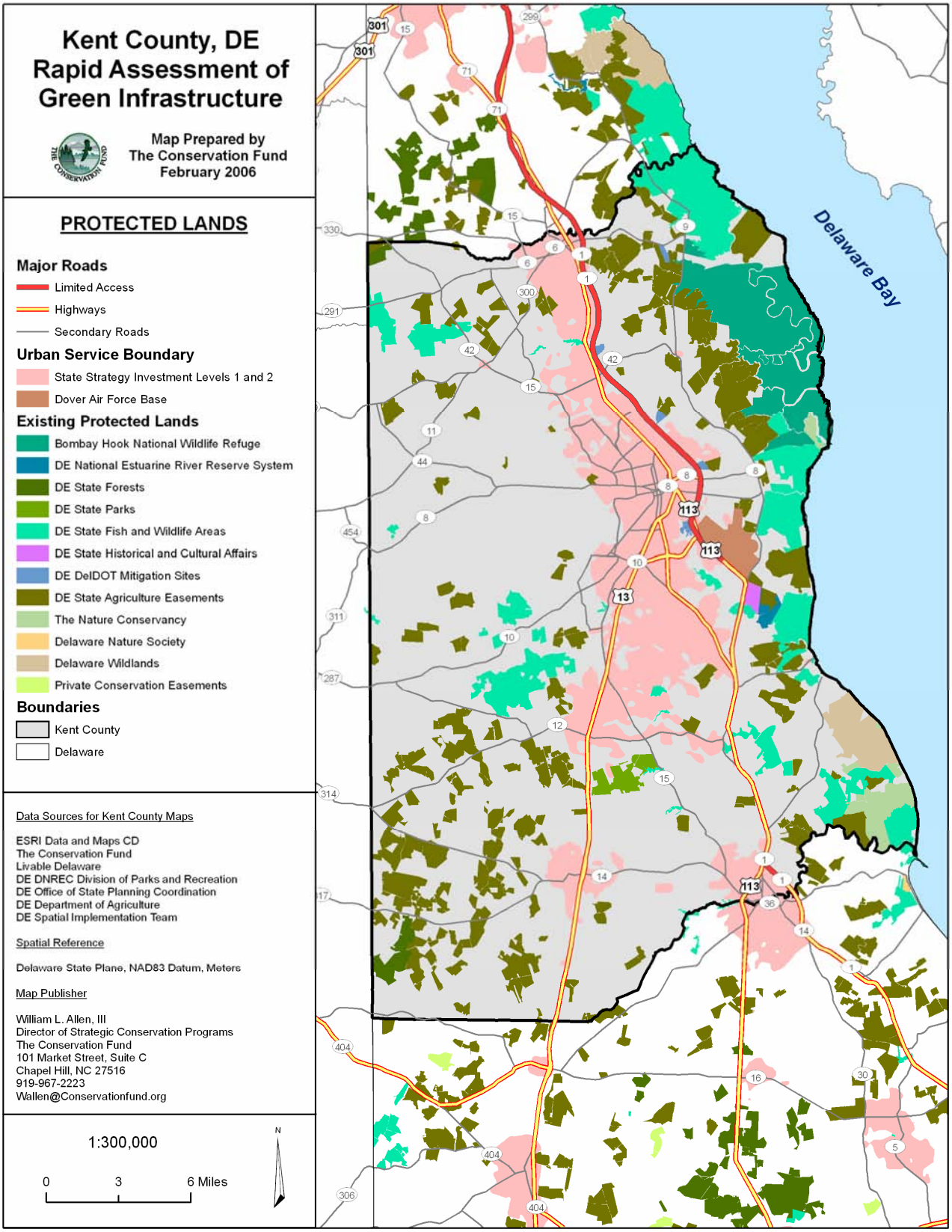
Delaware's Open Space Conservation Program

Delaware's Open Space Program was created on July 13, 1990 by the signing into law of the Land Protection Act and Subchapter II of the Realty Transfer Tax Act. The Land Protection Act formalized a process for acquiring state conservation lands. According to the law, state agencies may acquire any interest in real property for the following purposes:

- To protect and conserve all forms of natural and cultural resources.
- To protect and conserve biological diversity.
- To protect existing or planned parks, forests, wildlife areas, nature preserves or other recreation, conservation and cultural sites by controlling the use of contiguous or nearby lands.
- To preserve sites of special natural, cultural or geological interest.
- To connect existing open spaces into a cohesive system of greenways and resource areas.
- To provide for public outdoor recreation.
- To allow for water resource conservation.

Since the passage of the Land Protection Act in 1990 through 2004, the Open Space Program protected 43,286 acres of land at a total cost of $209,552,908.

Source: Livable Delaware


Kent County, DE
Rapid Assessment of
Green Infrastructure
Map Prepared by
The Conservation Fund
February 2006
PROTECTED LANDS
Major Roads
Limited Access
Highways
Secondary Roads
Urban Service Boundary
State Strategy Investment Levels 1 and 2
Dover Air Force Base
Existing Protected Lands
Bombay Hook National Wildlife Refuge
DE National Estuarine River Reserve System
DE State Forests
DE State Parks
DE State Fish and Wildlife Areas
DE State Historical and Cultural Affairs
DE DelDOT Mitigation Sites
DE State Agriculture Easements
The Nature Conservancy
Delaware Nature Society
Delaware Wildlands
Private Conservation Easements
Boundaries
Kent County
Delaware
Data Sources for Kent County Maps
ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team
Spatial Reference
Delaware State Plane, NAD83 Datum, Meters
Map Publisher
William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org
1:300,000
0
3
6 Miles
N
Delaware Bay

Working Landscapes Inventory

Agricultural lands protected by easement in Kent County encompass over 43,500 acres. The Fund identified over 1,095 parcels that were greater than 20 acres in size encompassing 96,271 acres of unprotected agricultural land in Kent County. This served as our baseline for tracking progress towards the *Livable Delaware* goal of protecting half of the remaining, unpreserved cropland. All agricultural land use in Kent County, based on 2002 data, encompasses over 180,000 acres (see map on opposite page).

Forested land use in Kent County, based on 2002 data, encompasses approximately 37,500 acres, of which 30,100 are unprotected. As mentioned in the DEN results, over half of this forestland (16,100 acres) falls within the DEN core forest areas, while the remaining 14,000 acres are likely a combination of working forest lands and buffers between agricultural fields.

Although the historic evaluation of the DALPF acquisition program is addressed in detail in a later section, this evaluation revealed findings that complement the working landscape inventory and can guide the next phase of agricultural land preservation within the *Livable Delaware* time horizon of 2024. The evaluation analyzed the $93 million of agricultural easement expenditures over the life of DALPF and found that comparable agricultural benefits potentially could have been achieved for about $25 million less had optimization been available in the decision making process. The evaluation also identified 60,000 acres as an appropriate target to achieve the *Livable Delaware* goal for productive farmland in Kent County and recommended an annual funding rate of between $4.5 million and $11.6 million with steady funding at $8 million directed towards Kent County annually to meet this target.

Delaware's Agricultural Lands Preservation Foundation

The Delaware Agricultural Lands Preservation Foundation was formed in July, 1991. Landowner participation in the program is voluntary and has two components. First, landowners join the program by creating an Agricultural Preservation District, which must contain at least 200 contiguous acres devoted to agricultural and related uses. Landowners who place their lands into Agricultural Preservation Districts agree to not develop their lands for at least 10 years, devoting the land only to agriculture and related uses. In return, the owners receive tax benefits, right-to-farm protection, and an opportunity to sell a preservation easement to the state that keeps the land free from development permanently. As of 2004, there were 134,747 acres in 564 Agricultural Preservation Districts and District expansions in Delaware. Out of the 134,747 acres in agricultural preservation districts, 411 properties encompassing approximately 76,848 acres have been permanently protected through the purchase of preservation easements for $90,523,212. In recent years, the funding source for development rights purchases has expanded to include both local and federal matching dollars. All three Delaware counties now contribute financial resources to the foundation effort. Delaware has also been very successful in obtaining federal farm preservation dollars.

Source: Livable Delaware

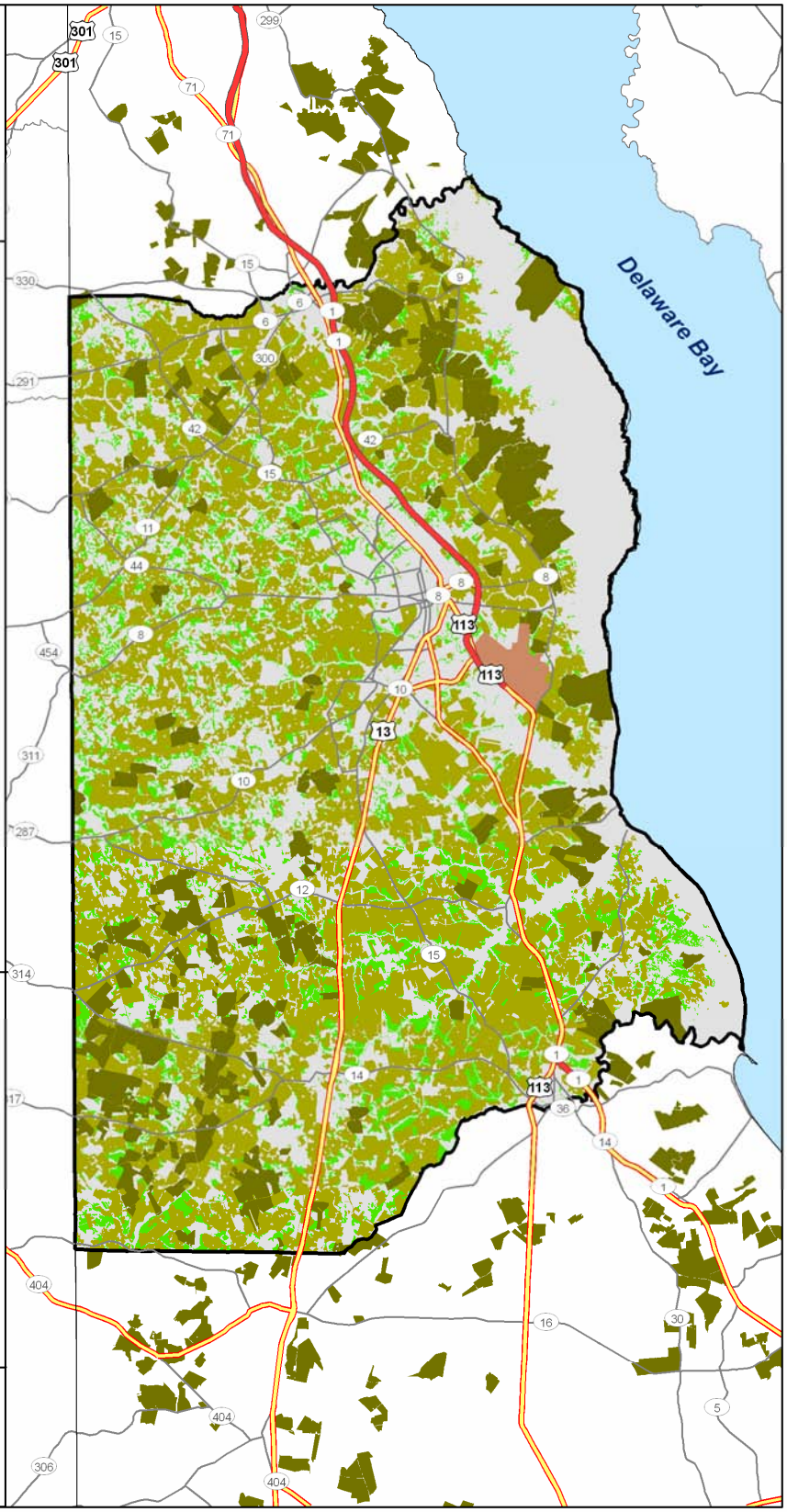
Kent County, DE Rapid Assessment of Green Infrastructure

Map Prepared by
The Conservation Fund
February 2006

FOREST AND AGRICULTURAL LAND USE

Major Roads
- Limited Access
- Highways
- Secondary Roads
- Dover Air Force Base

Boundaries
- Kent County
- Delaware
- Agricultural Easements
- Agriculture Land Use
- Forest Land Use



Data Sources for Kent County Maps

ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team

Spatial Reference

Delaware State Plane, NAD83 Datum, Meters

Map Publisher

William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org

1:300,000

0 3 6 Miles

N

leadership forum

After the DEN was delineated, the Fund convened the Kent County Green Infrastructure Leadership Forum. In October 2005, 23 stakeholders representing 18 public and private conservation partners attended the Forum at the St. Jones River Reserve outside the City of Dover. Forum participants provided feedback on the draft Rapid Assessment of Green Infrastructure in the form of qualitative information and quantitative data on weighting preferences of GIS layers.

On the qualitative side, stakeholders provided an overview of different data sources, a critique of the rapid assessment approach and updates on various policy initiatives at the local, county and state level. Stakeholders shared their organization's priorities as well as their views of obstacles to land conservation outcomes in Kent County.

Important quantitative data also was obtained using a conservation values scaling exercise. Stakeholders reviewed and prioritized mapping criteria and then assisted in developing GIS model factors and weights to be used in the suitability analysis and parcel scoring system. The Fund used a modified Analytical Hierarchy Process (AHP) to help establish the weights of factors in five categories: working farms, working forests, natural resources, core green infrastructure and better models for development (see box on opposite page for more details) . The Fund prepared a questionnaire that was completed by stakeholders at the Leadership Forum to express the weights of GIS layers to be used in the prioritization model. In particular, the Fund asked stakeholders to evaluate the value of core green infrastructure layers generated by the Fund, the state's LESA model layers for agricultural lands, several natural resource layers and the State's own Green Infrastructure Map. The results of the scaling exercise provided valuable input into the four suitability models that were utilized in the parcel scoring systems: working farms, working forests, natural resources, and *Better Models for Development*.

The Forum also provided an opportunity for Dr. Kent Messer, a resource economist with the Applied Economics and Management Department at Cornell University, to introduce the concept of measuring the cost-effective use of conservation

Kent County Green Infrastructure Leadership Forum Invited Representatives

City of Dover
Delaware Department of Agriculture
Delaware Department of Transportation
Delaware Division of Fish and Wildlife
Delaware Division of Parks and Recreation
Delaware Economic Development Office
Delaware Forest Service
Delaware Greenways
Delaware Office of State Planning Coordination
Delaware Wild Lands
Dover Air Force Base
The Nature Conservancy
Kent County Conservancy
Kent County Department of Planning Services
Kent County Levy Court
Kent County Parks Division
Kent County Tourism Convention & Visitors Bureau
U.S. Fish and Wildlife Service

investments through optimization of protection opportunities. Based on feedback from the Forum, the Fund decided to undertake an historic evaluation of the Delaware Agricultural Lands Preservation Foundation's purchase of development rights program (see Working Landscape Program Evaluation – Detailed Overview) as a means to enhance the current program and provide recommendations on the State's forest easement program.

The Leadership Forum also provided information on opportunities for collaboration on land conservation with non-traditional partners. The Conservation Fund's Will Allen provided a nationwide overview of collaborative land use partnerships with the U.S. Department of Defense. Ole Amundsen from Land Conservation and Planning discussed real estate tools used with schools and universities, while John Rogers from The Conservation Fund highlighted nationwide efforts involving carbon sequestration and potential application in Kent County.

Analytic Hierarchy Process, Pairwise Comparison, and Suitability Analysis

The Analytic Hierarchy Process (AHP) is a quantitative method for ranking decision alternatives by developing a numerical score to rank each decision alternative based on how well each alternative meets the decision maker's criteria. AHP relies on pairwise comparisons, which is a process where stakeholders compare the value of each individual criterion with every factor in their decision-making criteria, resulting in a matrix that reflects weights of all factors. When used in a conservation planning process, the stakeholders compare the relative values of GIS layers and data sets for determining the weights used in a particular suitability model.

Pairwise comparisons can be completed manually or electronically. For the Kent County Leadership Forum, the Fund utilized the manual approach by creating a written questionnaire that included the pairwise comparisons for each factor for all five suitability models. The results from each Forum member's questionnaire were tabulated the week following the meeting and entered into a specialized software package for pairwise comparison calculations. Expert Choice™ software automates the suitability model weight calculations and ensures that the results from the pairwise comparisons are logically consistent with one another. The software facilitates slight modifications to ensure that the consistency ratio is below an appropriate threshold. The final suitability weights were then incorporated into the suitability surface calculations into GIS software for further analysis. More information on the AHP, pairwise comparisons, and suitability analysis is available in the References section of this report.

Delaware Department of Agriculture's Land Evaluation / Site Assessment (LESA) System

The LESA system is a GIS-based decision making tool for the evaluation and prioritization of agricultural lands suitable for preservation within Delaware's purchase of development rights program. The Land Evaluation factor is a measurement of agricultural or forest productivity based on soils and land cover, while the Site Assessment factor measures multiple impacts on long-term productivity and other environmental, economic or social factors, including development potential, proximity to existing farming operations, utilization of farm programs, and biodiversity value of the parcel.

implementation quilt

As referenced in the book *Green Infrastructure: Linking Landscapes and Communities*, the implementation quilt is a framework for matching available resources – tools, programs, funding, and people – to the needs of the green infrastructure network. Every planning context, like every quilt, is unique. For Kent County, the quilt is an implementation strategy that identifies what tools can be used, who can use them, when the activity should be undertaken, and how it can be financed. The quilt also underscores the underlying principle of green infrastructure that natural resource and working lands should be identified and protected prior to development. Implementation tools for Kent County's quilt include land acquisition, conservation easements, purchase and transfer of development rights, zoning, and conservation development. The toolbox also includes refining land use planning policies and funding programs to allow users of these tools – Federal, State, and local governments and nonprofit organizations – to more effectively implement the 2024 *Livable Delaware* goals and protect Kent County's ecological network and working landscapes.

The greatest threat to implementation of *Livable Delaware* goals in Kent County is the haphazard growth currently taking place in areas designated as State Investment Level 4 in *State Strategies for Policy and Spending*. In the past two years in Delaware, 49% of land proposed for residential development was outside areas designated for growth (State Investment Levels 1 and 2) (Barrish, Cris. "Livable Delaware or Miserable Delaware?" News Journal, http://www.delawareonline.com).

While legislation is proposed that would limit development on about 450,000 rural acres across the state, the current proposal has been met with significant opposition. The proposed implementation quilt for Kent County attempts to develop a strategy that would alleviate this opposition while upholding the fundamental principles of *Better Models for Development in Delaware*.

Development Management Tools

First and foremost, the State and County should collaborate on the development of **planning overlay zones** that delineate protection areas for the Delaware Ecological Network and important working landscape areas. In addition, designated sending and receiving areas should be delineated for a **transfer of development rights** system that channels development into designated growth areas. For properties without appropriate development sites, the vested development rights could be donated by the landowner for a tax deduction or could be available for purchase either by developers seeking density bonuses for development within designated growth areas or by conservation land acquisition programs. In addition, the underlying permitted residential density in the overlay zones would drop to a very low level, such as one dwelling unit per 50 acres. The goal of the system for developers is to provide a higher return on investment for development in areas with existing infrastructure to support growth, to encourage higher densities and more affordable residential development in designated growth areas, and to create a predictable and fair regulatory environment. The goal of this system for landowners is to permit subdivision of their property for

family lots or small numbers of dwelling units, to facilitate the sale or donation of development rights to maintain their properties as working landscapes or important natural areas, and to provide certainty for financial planning of land assets.

Incorporation of green infrastructure into municipal planning also is essential. Specifically, Kent County's local jurisdictions should utilize the rapid assessment of green infrastructure to update their Comprehensive plans and to strengthen their policies on natural resource and working landscape protection through best management practices, site plan review, design review, and other tools. These municipal plan updates and policy changes also should be consistent with the cluster development and transfer of development rights provisions outlined for the overlay zones. Non-profit organizations, such as the Kent County Conservancy, can incorporate the green infrastructure network into their land acquisition priorities. County and municipal governments as well as farm interests also could launch initiatives that **support the working landscape economy**, including tourism, farm stewardship cooperatives, or locally branded agricultural products.

Land Conservation Tools

The recommendations in this section are focused on leveraging funds and refining the geographic scope in Kent County for the State's three primary land acquisition programs: the Open Space Conservation Program, the Delaware Agricultural Land Preservation Foundation (DALPF), and the Forestland Preservation Program.

Within Kent County, the State's Open Space Conservation Program's primary focus for its acquisition funding should be on coastal and aquatic systems. Priority projects would fall within approximately 22,600 acres identified within the Delaware Ecological Network. Targeting these lands enhances the leverage opportunities with three key Federal funding sources: the Land and Water Conservation Fund (LWCF), the North American Wetlands Conservation Act (NAWCA), and the Coastal and Estuarine Land Conservation Program (CELP). The Program's secondary focus should be the protection of delineated inland core forests most suitable as wildlife habitat and interior forest lands. Focusing on these areas will help protect the conservation and recreation priorities for Kent County outlined in *Livable Delaware*.

The State's new Forestland Preservation Program's primary focus should be the protection of core forests within the DEN most suitable as commercially viable forests appropriate for voluntary, working forest conservation easements. This also will help leverage two key Federal funding sources: the USDA Forest Legacy Program and the USDA Farm and Ranchland Protection Program. Further analysis is needed to determine the capital needs of the Forestland Preservation Program to achieve

the *Livable Delaware* goal of protecting half of the remaining commercially viable forest.

Based on the historic evaluation of the DALPF Program, about 60,000 acres of productive cropland should be protected by 2024 to achieve the *Livable Delaware* goals. The evaluation recommended an annual funding rate of between $4.5 million and $11.6 million with steady funding at $8 million annually to meet this target. The evaluation also highlighted the need for additional considerations in the purchase of development rights program. Specifically, the optimization technique known as cost effective analysis could be effective in protecting more acreage of productive farmland at the same budget level. This same technique also could be applied to the new forestland easement program.

Next Steps

The Fund realizes that completing the implementation quilt for Kent County will require significant collaboration among Federal, State, local, and non-profit partners working in partnership with developers, landowners, and the general public. Working together will be essential for protecting the State's $200 million plus conservation and working landscape investments and ensuring a livable Delaware. The Fund suggests that the Kent County Green Infrastructure Leadership Forum reconvene to review the results of the rapid assessment and formulate a strategy to address its recommendations. This meeting also can determine the value of the Fund's GIS-based decision support tool to help proactively identify new land conservation opportunities and evaluate related protection projects as they arise in Kent County. Ultimately, the Fund hopes that the Kent County Rapid Assessment of Green Infrastructure will serve as a framework for future strategic conservation and land planning activities and facilitate the leveraging of resources to implement the goals of Kent County's Federal, State, local and private conservation partners.

Photo: Courtesy of The Conservation Fund

The Delaware Ecological Network:

DETAILED OVERVIEW

core forests

The Fund defined core forests as contiguous areas of relatively undisturbed, mature forest, at least 100 hectares in size. The Fund used forest interior dwelling bird species (FIDS) as indicators of high-quality forest. Areas that meet the breeding habitat requirements of FIDS also provide habitat for other animals and plants that rely on undisturbed forest. First, forest cover was identified from land use/land cover and other data. Then, the Fund delineated forest patches, which are contiguous areas of forest bounded by non-forest, paved roads, or active railroads. Delaware's land is only 34% forested, and most of this remaining forest is fragmented into small patches, less than 100 hectares. Finally, the Fund used a variety of data to identify core forest areas. Core forest had to meet the following criteria, based on reviews of FIDS habitat requirements (Bushman and Therres, 1988; Robbins et al., 1989; Herkert et al., 1993; Hodges and Krementz 1996; Jones et al., 2000; Blackbird-Millington Corridor Conservation Area Plan, 2004; and Roswell, 2004) and examination of the data:

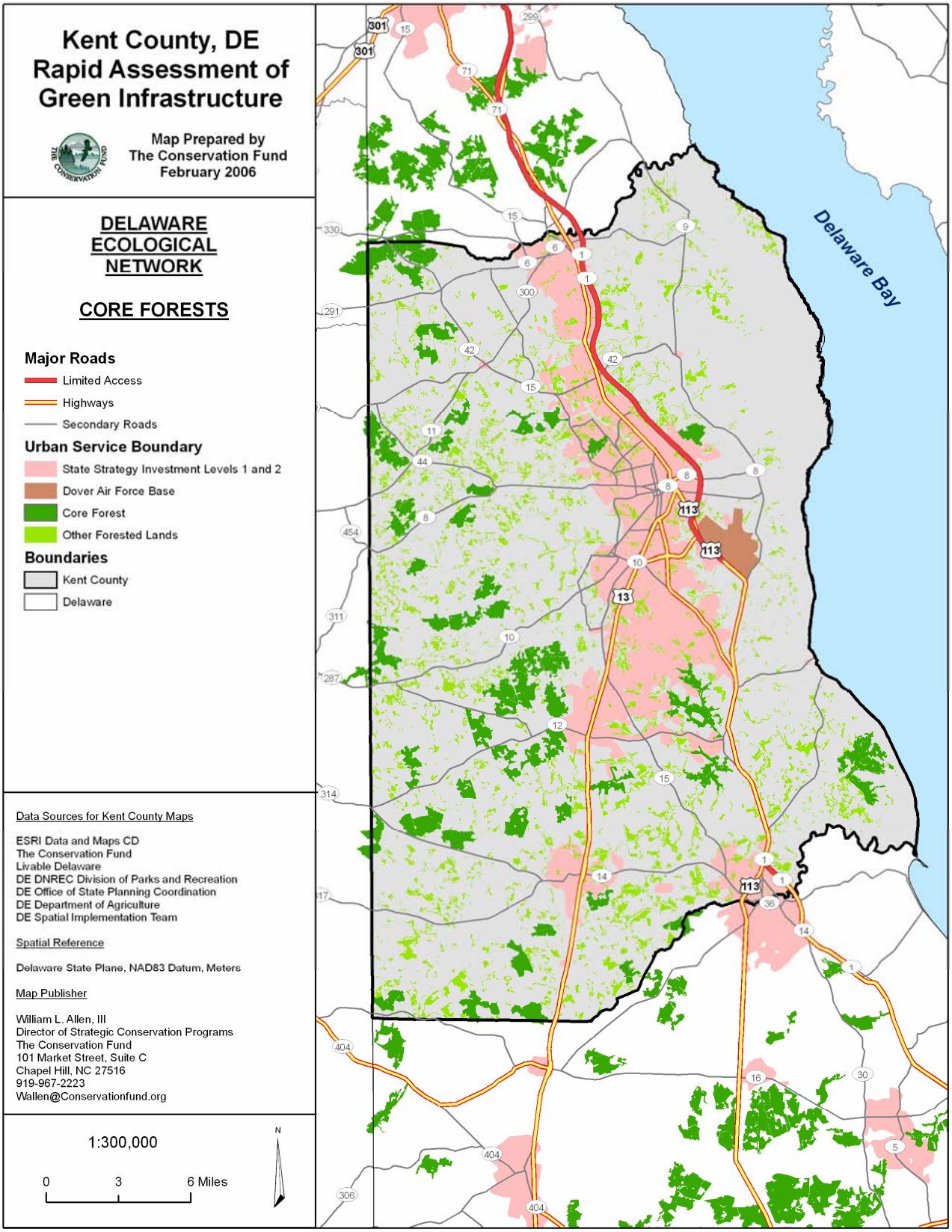
- At least 100 hectares in size;
- At least 50%, or 100 hectares of, mature broadleaf forest except areas historically dominated by conifers;
- At least 20% of forest greater than 100 meters from edge;
- At least 200 meters deep in spots;
- At least 25% forest cover within 2 kilometers; and
- Contain one or more of the following:
  - ⇒ Perennial streams or other water, with riparian forest at least 200 meters wide on average;
  - ⇒ Large permanently or seasonally flooded wetlands;
  - ⇒ Contiguous forest area of greater than 200 hectares;
  - ⇒ Rare communities or mature forest;
  - ⇒ One of the following indicator species of mature, unbroken forest: American Redstart, Barred Owl, Brown Creeper, Cerulean Warbler, Delmarva Fox Squirrel, Hooded Warbler, Northern Parula, Red-Shouldered Hawk, or Yellow-Throated Warbler;
  - ⇒ Area within Delaware's Natural Areas Inventory, which contains Delaware's best examples of native plant and animal communities, old growth forests, wetlands, rare and endangered species sites and archeological and geological sites;
  - ⇒ Area within a Nature Conservancy (TNC) matrix block;
  - ⇒ At least 725 meters maximum depth; or
  - ⇒ At least 75% mature forest.

Areas meeting the above requirements were then compared to aerial photos in order to filter out pine plantations. Most of these were in Sussex County.

Forest Inventory and Analysis (FIA) data indicated that forest in core areas was more likely to be mature than forest outside core areas. The Fund did not have enough data to make other inferences.

Core Forest in Delaware

188 areas
Size 100-1440 ha
Mean 200 ha
Total 37,298 ha
7.4% of DE land


Kent County, DE
Rapid Assessment of
Green Infrastructure
Map Prepared by
The Conservation Fund
February 2006
DELAWARE
ECOLOGICAL
NETWORK
CORE FORESTS
Major Roads
Limited Access
Highways
Secondary Roads
Urban Service Boundary
State Strategy Investment Levels 1 and 2
Dover Air Force Base
Core Forest
Other Forested Lands
Boundaries
Kent County
Delaware
Data Sources for Kent County Maps
ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team
Spatial Reference
Delaware State Plane, NAD83 Datum, Meters
Map Publisher
William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org
1:300,000
0
3
6 Miles
N
Delaware Bay

core wetlands

The Fund defined core wetlands as contiguous natural areas with at least 10 hectares of relatively unimpacted wetlands. The Fund used four wetland-dependent birds (Prothonotary Warbler, Louisiana Waterthrush, Northern Parula, and King Rail), as well as salamanders and turtles, as indicators of high-quality wetland habitat (Bushman and Therres, 1988; Semlitsch and Jensen, 2001; Mason et al, 2005). In theory, areas that meet the habitat requirements of these animals also provide habitat for other animals and plants that rely on undisturbed wetlands.

Photo: U.S. Fish & Wildlife Service/K.C.Liehr

First, wetlands were identified from state and federal data. From these, the Fund selected wetlands that had not been ditched, drained, excavated, converted to pine plantations or farms, or otherwise heavily modified. The Fund also removed areas less than 30 meters from development, agriculture, clearings, and roads. From these relatively unimpacted wetlands, the Fund selected the following:

- Riparian forested wetland at least 300 meters wide on average and 100 contiguous hectares;
- At least 60 hectares of contiguous marsh;
- Wetlands surrounded by at least 210 meters of forest or other wetland;
- Wetlands containing rare species or communities; or
- Wetlands in a designated natural area.

If there were at least 10 hectares of wetlands meeting these conditions within a contiguous natural area, that contiguous area was designated a core wetland area.

Core Wetlands in Delaware

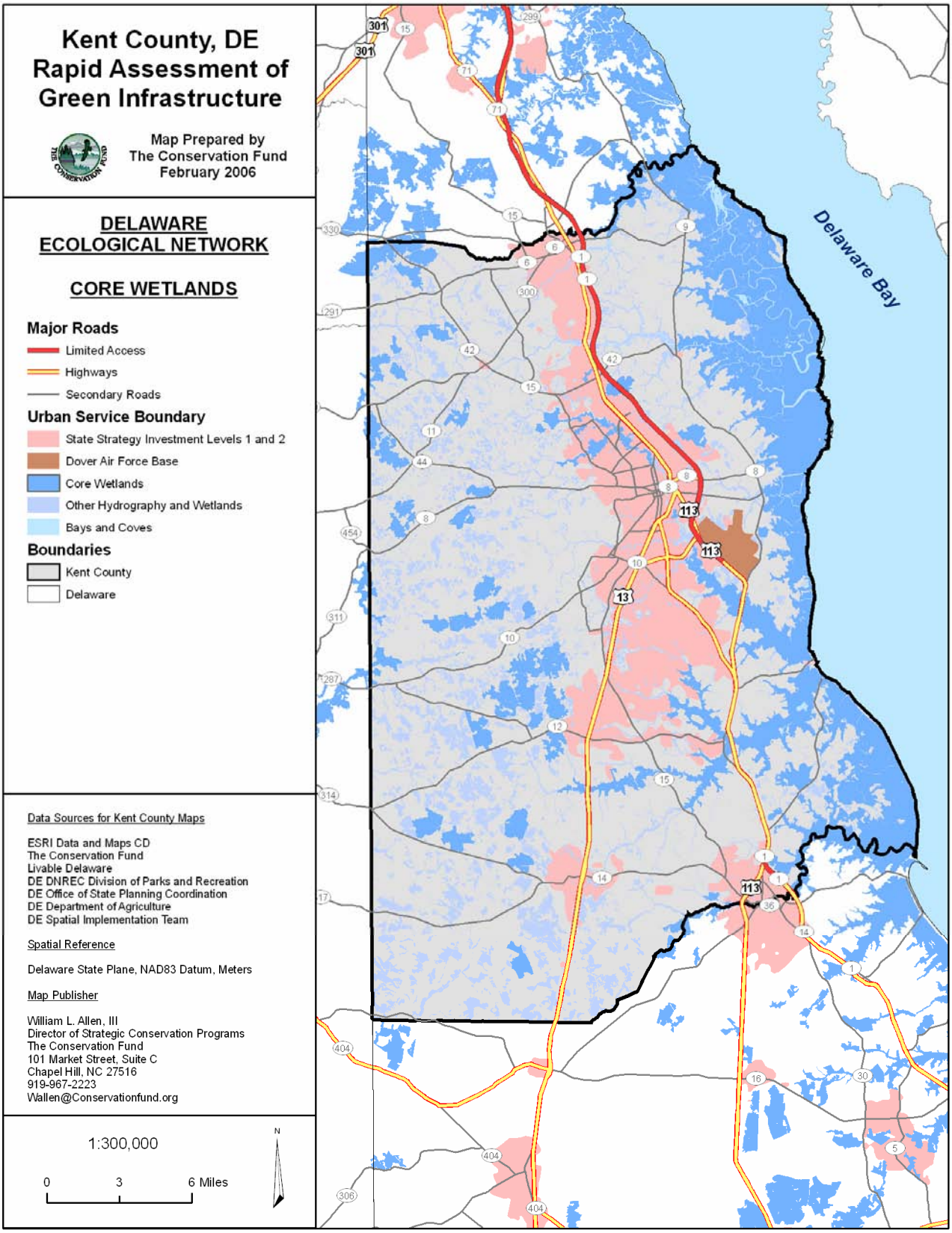
Total 76,696 ha
15.2% of DE land

As with core forest, areas meeting these requirements were then compared to aerial photos in order to filter out pine plantations. There were five such areas, all in Sussex County.

There was some overlap between core forest and core wetlands.

Data collected by Delaware Department of Natural Resources & Environmental Control (DNREC) in the Nanticoke watershed indicated that riverine or flat wetlands, at least in this watershed, are likely to be in better condition if they are in core wetland areas than if they are outside these areas.

Photo: Maryland Dept. of Natural Resources/Ted Weber


Kent County, DE
Rapid Assessment of
Green Infrastructure
Map Prepared by
The Conservation Fund
February 2006
DELAWARE
ECOLOGICAL NETWORK
CORE WETLANDS
Major Roads
Limited Access
Highways
Secondary Roads
Urban Service Boundary
State Strategy Investment Levels 1 and 2
Dover Air Force Base
Core Wetlands
Other Hydrography and Wetlands
Bays and Coves
Boundaries
Kent County
Delaware
Data Sources for Kent County Maps
ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team
Spatial Reference
Delaware State Plane, NAD83 Datum, Meters
Map Publisher
William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org
1:300,000
0
3
6 Miles
N
Delaware Bay

core aquatic systems

Core aquatic areas contain at least 1 kilometer of relatively unimpaired streams, plus their associated riparian forest and wetlands. The Fund considered only freshwater streams and rivers; bays and estuaries are only included indirectly (e.g., they are impacted by land use upstream). Most of Delaware's streams are ditched or otherwise degraded. For example, the Nanticoke watershed is over 90% channelized. Fully functional streams are not only rare, but fragmented: separated by unbuffered or channelized reaches, dams, road culverts, pollution inputs, etc.

Like forests and wetlands, stream health is a function of both local and landscape conditions. Stream stability and aquatic habitat quality depend not only on riparian cover, morphology, etc. in the immediate vicinity, but also on the amount and intensity of land and hydrologic alteration in the drainage area upstream. Thus, the Fund first attempted to identify the least-impacted watersheds in Delaware.

To do so, the Fund collected data at 47 unmodified, non-tidal stream reaches throughout the state, and compared this to land cover and human impacts in their upstream catchments. Catchment boundaries were manually delineated for each sample site. Although stream variability was high, and no sites were absolutely pristine, the Fund found that conditions were generally better in watersheds with >45% riparian forest or wetland buffers and <10% impervious surface.

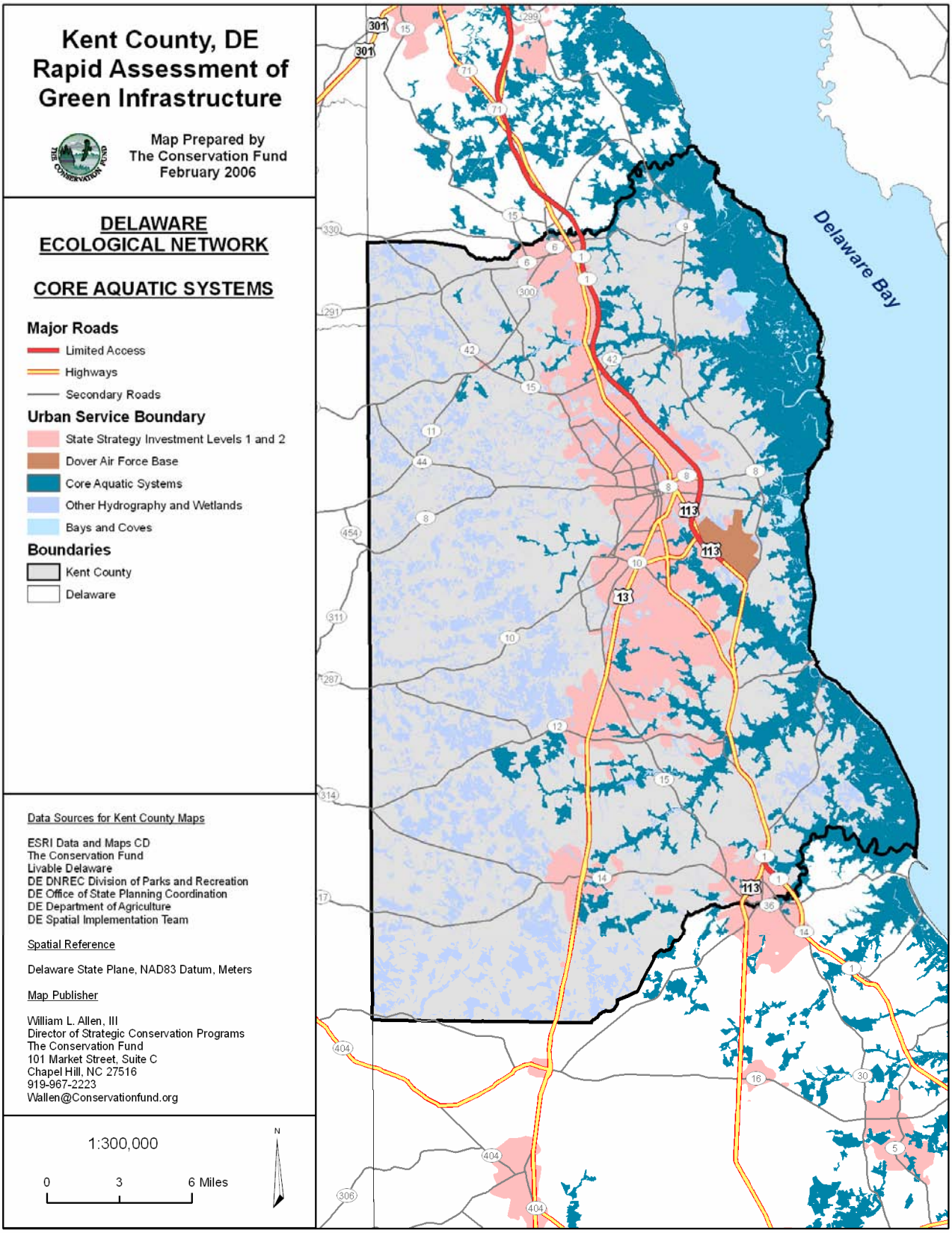
The Fund extrapolated these thresholds to the whole state, identifying those state-defined HUC-13 (generally 3rd order) watersheds most likely to contain relatively unimpaired streams. 49 of 74 (66%) HUC-13 watersheds had >45% riparian forest or wetland and <10% impervious surface. Of these, 5 in the Nanticoke watershed were >90% channelized, and omitted. Comparing the resulting 44 "core watersheds" to the field data, 82% of sites scoring "Optimal" for eutrophication, 100% of sites scoring above "Marginal" for sedimentation, and 79% of sites scoring "Optimal" for flashiness were included.

The next step was to identify core streams within the least-impacted watersheds. These were streams that were unchannelized and unimpounded, contained riparian forest or marsh on both sides of the bank, and were not constrained by dams, road crossings (except for bridges), or other stream blockages. Core streams had to run at least 1 kilometer with the above conditions. The Fund also added natural streams containing rare fish, mussels, or salamanders, if they were not already included.

To define core aquatic areas, the Fund identified forests and wetlands containing core streams. These ranged from narrow (60 meters wide) riparian buffers to large contiguous blocks such as White Clay Creek Valley or the Nanticoke River floodplain. There was some overlap between core aquatic areas and core forests and wetlands. Available data in Delaware did not reliably indicate stream condition (e.g., channelizing, impounding, pollution, or species present), so field verification is highly recommended before implementing conservation measures.

Core Aquatic Areas in Delaware

About 2700 km (24%) of state's streams & rivers
About 67,000 ha of forest & wetland
13.3% of DE land


Kent County, DE
Rapid Assessment of
Green Infrastructure
Map Prepared by
The Conservation Fund
February 2006
DELAWARE
ECOLOGICAL NETWORK
CORE AQUATIC SYSTEMS
Major Roads
Limited Access
Highways
Secondary Roads
Urban Service Boundary
State Strategy Investment Levels 1 and 2
Dover Air Force Base
Core Aquatic Systems
Other Hydrography and Wetlands
Bays and Coves
Boundaries
Kent County
Delaware
Data Sources for Kent County Maps
ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team
Spatial Reference
Delaware State Plane, NAD83 Datum, Meters
Map Publisher
William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org
1:300,000
0
3
6 Miles
N
Delaware Bay

hub delineations and rankings

The rapid assessment revealed significant overlaps between core forests, wetlands, and aquatic areas. The Fund combined these core areas, and added other natural areas (e.g., beaches) missed by these delineations. Other natural areas were added if they were at least 10 hectares; and they contained rare species or communities; or were within Natural Areas Inventory sites, state parks, state Fish and Wildlife areas, or National Wildlife Refuges. The Fund discarded "tendrils" and other portions dominated by edge effects.

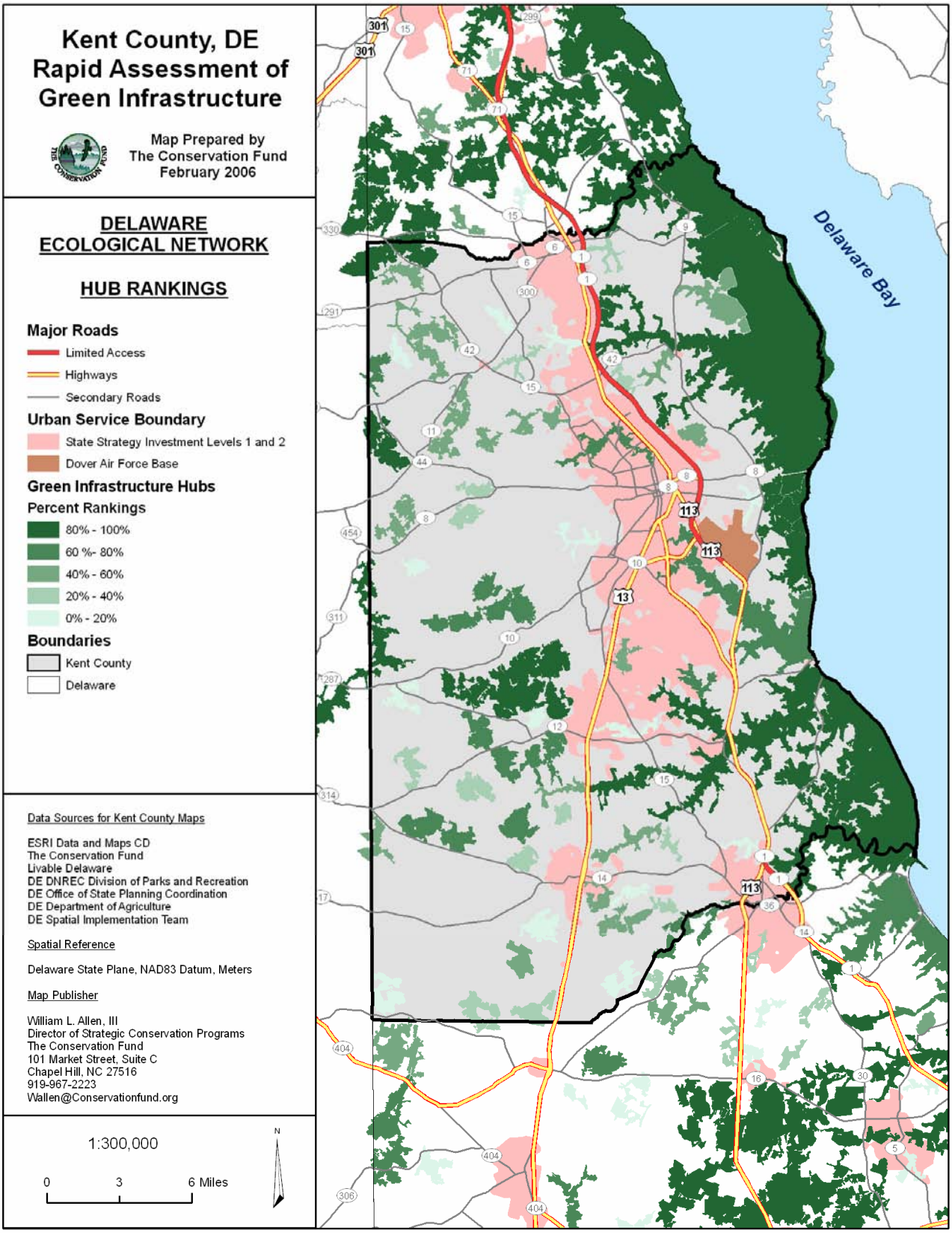
The Fund then identified hubs, defined as aggregations of core areas divided by major roads or gaps >100 meters wide. Hubs were at least 100 hectares in size, and contained one or more core areas, as well as adjacent natural land and agricultural buffers. Not all core areas fell within hubs, if they were isolated and <100 hectares.

ECOREGION	# OF CORE AREAS	AREA IN CORES (ha)
Barrier Islands/Coastal Plain Flatwoods	29	16,394
Delaware River Terraces and Uplands	69	39,735
Delmarva Uplands	625	66,295
Piedmont Uplands	72	4,521

Core areas and hubs comprise 28% of Delaware's land. To help prioritize protection efforts, the Fund ranked these areas according to their relative ecological importance. Rankings were calibrated by ecoregion, displayed in the chart above for reference. Next, the Fund computed 20

Photo: The Conservation Fund/Ted Weber

ecological parameters for each core area. Three of these ecological parameters were dropped because they were highly correlated with other parameters. The Fund transformed many of the remaining variables to increase spread evenness (e.g., taking the square root). For each variable, the Fund then divided the transformed value for each core area by the maximum in its ecoregion, giving a score between 0 and 1. Next, transformed variables were weighted according to their ecological importance, and summed to derive an overall percentile rank for each core area within its ecoregion. The Fund compared several different weighting schemes (including weighting all variables equally), but overall core ranks did not change significantly (98-100% correlation) as weights were changed. This was encouraging; that the same areas (e.g., Great Cypress Swamp, Nanticoke River, White Clay Creek, Blackbird Creek watershed, Bombay Hook and other coastal wetlands, and Rehoboth-Indian River Bays) were identified as particularly important regardless of how the Fund prioritized the data.


Kent County, DE
Rapid Assessment of
Green Infrastructure
Map Prepared by
The Conservation Fund
February 2006
DELAWARE
ECOLOGICAL NETWORK
HUB RANKINGS
Major Roads
Limited Access
Highways
Secondary Roads
Urban Service Boundary
State Strategy Investment Levels 1 and 2
Dover Air Force Base
Green Infrastructure Hubs
Percent Rankings
80% - 100%
60 %- 80%
40% - 60%
20% - 40%
0% - 20%
Boundaries
Kent County
Delaware
Data Sources for Kent County Maps
ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team
Spatial Reference
Delaware State Plane, NAD83 Datum, Meters
Map Publisher
William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org
1:300,000
0
3
6 Miles
N
Delaware Bay

VARIABLE	WEIGHT	VARIABLE	WEIGHT
Square root of weighted score of rare species or community occurrences	3	Square root of number of unmodified wetland types	1
Number of GAP vegetation types	2	Square root of mean distance to nearest edge	2
Square of # of GAP modeled vertebrate species	2	Is the core area in a hub? (1 = yes)	3
Presence of old growth forest	1	% mature broadleaf forest within 1 km	1
Square root of mature broadleaf forest area	2	% minimally impacted wetlands within 1 km	1
Square root of minimally impacted wetland area	2	Square root of unchannelized stream length within 1 km	1
Square root of unchannelized stream length	2	% forest or wetlands within 2 km	1
% in Natural Areas Inventory	2	Square root of mean distance to nearest major road	1
% in TNC matrix block	1		

After examining the data, the Fund chose the above weighting scheme.

Hubs were also ranked within their ecoregion, combining two variables:

- Total core area within the hub (transformed by taking the square root).
- Mean area-weighted rank of cores within the hub, plus type of non-core land (natural cover was most preferable, agriculture in the middle, and developed land the least preferable).

Both variables were calibrated by ecoregion, giving a score between 0 and 1; then summed to determine hub percent ranks by ecoregion.

Photo: The Conservation Fund/Ted Weber

corridors

Corridors are linear features linking core areas together, to allow animal and plant propagule movement between them, in the hope of maintaining viable and persistent metapopulations. The Fund assessed the landscape between core areas for its linkage potential, identifying conduits and barriers to wildlife and seed movement. Mirroring habitat definitions for core areas, corridor suitability was classified into three groups: forest, wetland, and aquatic. In general, preference was given to interior forest and wetland (the deeper, the better) and unmodified streams with wide riparian buffers. Urban areas were avoided, as were major roads (except where bridges cross floodplains). A GIS technique called least-cost path analysis was used to determine the best linkages between core areas.

The landscape features (see chart below) determined linkage suitability.

The Fund examined the computer-generated linkages and edited them where necessary. The Fund manually added linkages to those core areas (especially if they were in hubs) for which no linkages were calculated, if a logical pathway existed. Conversely, the Fund deleted some unnecessary or marginal linkages. Multiple pathways between the same core areas provide redundancy against disturbance or conversion to incompatible land use, so only a few linkages were deleted.

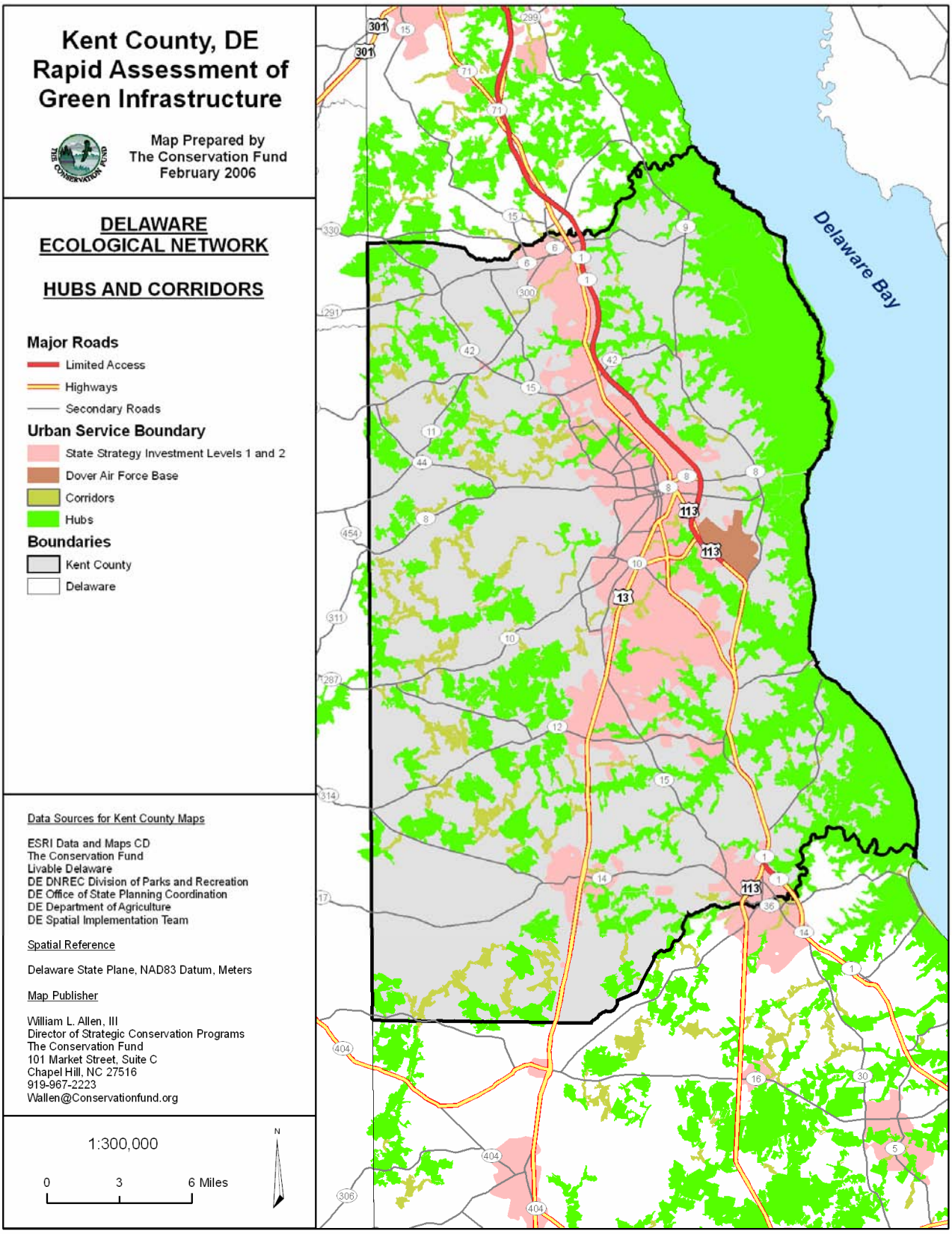
Once the Fund determined the best potential linkages between core areas, it delineated corridors by adding adjacent forest and wetland. Corridors should be at

LINKAGES BETWEEN CORE FOREST	LINKAGES BETWEEN CORE WETLANDS	LINKAGES BETWEEN CORE STREAMS
Land cover: Forest was the easiest to traverse, then other natural land, then grass, then agriculture. Developed areas and large water bodies were considered impassable.	Land cover: Wetlands were the easiest to traverse, then other natural land, then grass or sand, then agriculture. Developed areas and large water bodies were considered impassable.	Land cover: Only water was passable. Bays and coves were less passable than fresh water.
Mature forest was more suitable than young forest.		Streams: Unchannelized and unimpounded streams were more suitable than modified streams, ditches, etc.
Roads: The difficulty of crossing roads was a function of paved vs. unpaved, width, and traffic. Unimproved roads were much easier to cross than major highways (which were considered impassable).	Roads: The difficulty of crossing roads was a function of paved vs. unpaved, width, and traffic. Unimproved roads were much easier to cross than major highways (which were considered impassable).	Road-stream crossings were a barrier except at bridges. Since no details were available on culvert size and placement, these were all treated the same. Dams were a greater barrier.
Forest adjacent to water was more suitable.	Land adjacent to water was more suitable.	Streams with riparian forest or wetland were more suitable.
Interior forest was more suitable. The further from the forest edge, the more suitable.	Interior unmodified wetlands were more suitable. The further from the wetland edge, the more suitable.	The wider the riparian buffer, the better.
Designated natural areas were more suitable.	Designated natural areas were more suitable.	Designated natural areas were more suitable.
Protected land was more suitable.	Protected land was more suitable.	Protected land was more suitable.
Hubs were more suitable.	Hubs were more suitable.	Hubs were more suitable.

least 200 meters wide (Hodges and Krementz, 1996; Jones et al., 2000; Vidra, 2004); where this is not the case, reforestation might be considered, especially on hydric soils.

Corridors can be prioritized according to the importance of the areas they link, contribution to species viability, continuity, and feasibility of protection.

Photo: Maryland Dept. of Natural Resources /Ted Weber


Kent County, DE
Rapid Assessment of
Green Infrastructure
Map Prepared by
The Conservation Fund
February 2006
DELAWARE
ECOLOGICAL NETWORK
HUBS AND CORRIDORS
Major Roads
Limited Access
Highways
Secondary Roads
Urban Service Boundary
State Strategy Investment Levels 1 and 2
Dover Air Force Base
Corridors
Hubs
Boundaries
Kent County
Delaware
Data Sources for Kent County Maps
ESRI Data and Maps CD
The Conservation Fund
Livable Delaware
DE DNREC Division of Parks and Recreation
DE Office of State Planning Coordination
DE Department of Agriculture
DE Spatial Implementation Team
Spatial Reference
Delaware State Plane, NAD83 Datum, Meters
Map Publisher
William L. Allen, III
Director of Strategic Conservation Programs
The Conservation Fund
101 Market Street, Suite C
Chapel Hill, NC 27516
919-967-2223
Wallen@Conservationfund.org
1:300,000
0
3
6 Miles
N
Delaware Bay

suitability analysis and parcel rankings

Armed with the DEN and the suitability model factors and weights from the Leadership Forum, the Fund undertook GIS-based suitability analysis to derive resource-based suitability models and parcel scoring systems for Kent County. Using ESRI's ArcGIS™ software, the Fund developed suitability surfaces with 10-meter raster cell resolution that assigned relative values to forest, wetland, and aquatic system features. In addition, surfaces were created to assign values for a cell's relative proximity to existing protected lands and whether a cell fell within the boundary of the *Livable Delaware* Green Infrastructure Map features. The table below provides a brief summary of the suitability surface values for the five primary suitability surfaces.

SUITABILITY SURFACE TABLE

SURFACE	HIGH SUITABILITY	MEDIUM SUITABILITY	LOW SUITABILITY
Forests	Core Forest Area	Hub outside core, mature non-hub forest	Non-forest
Wetlands	Core Wetland Area	Non-core unmodified wetland	Modified wetland, non-wetland
Aquatic	Core Aquatic Area	Riparian, unchannelized	Riparian along ditch, non-riparian
Livable Delaware	Inside GI Boundary	n/a	Outside GI Boundary
Proximity	Within 100m of Protected land	Between 100-800m	>800m from protected land

The highest scores for each cell on the suitability surface were assigned a value of 9, while the lowest scores were assigned a value of 1. These surfaces were combined to create composite suitability surfaces, including a core green infrastructure surface that utilized a weight of 1/3 for each factor: core forests, core wetlands, and core aquatic systems. The core green infrastructure surface was integrated with the State's LESA system to develop a scoring system for working landscape parcels. The core forest, wetland, and aquatic system surfaces were integrated with the *Livable Delaware* Green Infrastructure Map and proximity to protected lands to develop a scoring system for natural resource and recreation priorities.

The parcel scoring system was linked to the State Investment Levels outlined in *State Strategies for Policy and Spending*. For State Investment Levels 3 and 4, scores were calculated to measure a parcel's suitability as a working farm, working forest, or natural resource priority. For State Investment Levels 1-3, the Fund attempted to map the first principle in *Better Models for Development in Delaware*, which states that **one should first identify where not to develop**. Scores were calculated to measure a parcel's suitability as an element of the green infrastructure network that would link the more urbanized parts of Kent County with the lands intended to support cropland, commercially viable forestland, and natural resource and recreation priorities.

Leadership Forum Pairwise Comparison **Results**

Natural Resources Suitability

Proximity to Existing Protected Lands	36%
Livable Delaware Green Infrastructure Map	18%
DEN Core Forests	16%
DEN Core Aquatic Systems	16%
DEN Core Wetlands	14%

Core Green Infrastructure Suitability

DEN Core Forests	34%
DEN Core Wetlands	33%
DEN Core Aquatic Systems	33%

Better Models for Development Suitability

DEN Core Green Infrastructure	40%
Proximity to Existing Protected Lands	40%
Livable Delaware Green Infrastructure Map	20%

Working Forests Parcel Scoring

LESA System – Site Assessment Score	56%
DEN Core Green Infrastructure	32%
LESA System – Land Evaluation Score	12%

Working Farms Parcel Scoring

DEN Core Green Infrastructure	58%
LESA System – Site Assessment Score	31%
LESA System – Land Evaluation Score	11%

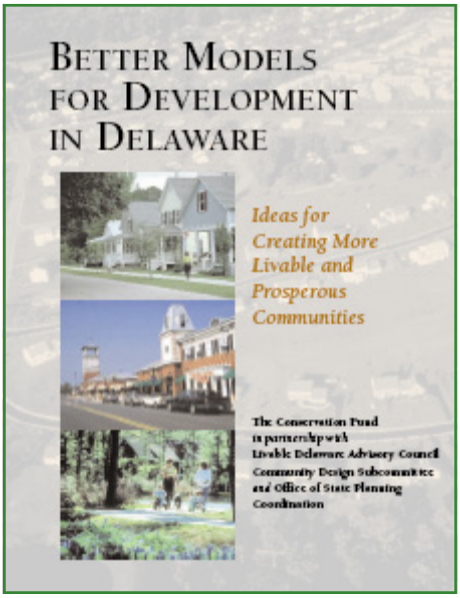


Photo: The Conservation Fund/Ted Weber

DELAWARE ECOLOGICAL NETWORK – CORE DATA ELEMENTS			
DATA LAYER	**ORIGINAL SOURCE**	**GROUND CONDITION DATE**	**SPATIAL RESOLUTION**
Land Use / Land Cover	EarthData International of Maryland, LLC for the Delaware Spatial Data Implementation Team	2002	1 foot
Land Cover	US Geological Survey (USGS) Multi-Resolution Land Characteristics (MRLC) National Land Cover Dataset (NLCD)	1999-2001	30m pixel
Impervious Surface	Mid-Atlantic Regional Earth Science Application Center (RESAC) Chesapeake Bay Watershed Impervious Surface	1999-2001	30m pixel
Streams outside Nanticoke Watershed	USGS Delaware Hydrography	1973-1993	1:24,000
Streams in Nanticoke Watershed	US Fish and Wildlife Service (USFWS)	1998	1:40,000
Floodplains	Federal Emergency Management Agency (FEMA) Q3 data	1995	1:24,000
Wetlands	Delaware Department of Natural Resources and Environmental Control (DNREC) System-Wide Monitoring Program (SWMP)	1992	unknown
Wetlands	USFWS National Wetlands Inventory (NWI)	1970s and 1980s	1:24,000
Subwatersheds	DNREC	N/A	unknown
DE Roads	Delaware Department of Transportation	2001	3 m
DE Roads	USGS	1973-1993	1:24,000
Railroads	USGS	1973-1993	1:24,000
MD and PA Roads	Tele Atlas North America, Inc/Geographic Data Technology, Inc. for ESRI Data and Maps CD	2005	1:100,000
Protected Lands	DNREC Division of Parks and Recreation, DNREC Division of Fish and Wildlife, Delaware Department of Agriculture (DDA), USFWS	varies	varies
Natural Areas	DNREC Natural Areas Program	2002	1:3,000
Rare Species Locations	DNREC Division of Fish and Wildlife		
GAP Vegetation Alliances	Mid-Atlantic GAP Analysis Program	1991-3	Minimum mapping unit of 2 ha
Native Vertebrate Species Models or Richness	Mid-Atlantic GAP Analysis Program	1991-3	Hex or quad range distribution
1937 Forest Cover	DNREC Natural Areas Program	1937	Unknown
EPA Ecoregions	US Environmental Protection Agency (US EPA)	Unknown	1:250,000
Soil Types	Natural Resources Conservation Service (NRCS) STATSGO	Unknown	1:250,000
Topography	University of Delaware Spatial Analysis Lab Digital Elevation Model (DEM)	Unknown	30 m
Dams	US EPA BASINS	1999	>50m

Working Landscape Program Evaluation:

DETAILED OVERVIEW

overview

A critical step in the protection of Kent County's green infrastructure is the maintenance and enhancement of its working landscapes. The Fund has undertaken an historical analysis of the DALPF program based on measuring its conservation benefits and cost effectiveness. The Fund has utilized the findings from this analysis to determine the financial resources necessary to achieve Kent County's share of the *Livable Delaware* goal of protecting 50% of the remaining, unpreserved cropland in Delaware. Policy and funding recommendations also are included to help achieve the cropland goal as well as the *Livable Delaware* goals to protect 50% of the remaining, unpreserved, commercially viable forest and 100% of the conservation and recreation priorities.

The working landscape program evaluation relies on appropriate measurements of benefits and costs and the utilization of three primary tools: the Rank-Based Model (RBM), the DALPF Program Model (DALPF), and the Optimization Model (OM). Each of the three models presented approach the question of which agricultural lands to protect in a different way. A commonality to all of these models is the concept of a parcel's conservation "benefit". Common metrics for benefits include number of acres, soil productivity, whether the farm is owner-occupied, and the contributions of the project to the core Green Infrastructure. Ultimately, what qualifies as a "benefit" in this context and how these benefits are measured is determined by the priorities and values of the conservation organization, not the model. The models instead accept the benefit measurements as givens and then seek to determine a set (or portfolio) of acquisitions following the specified selection approach.

Rank-Based Model

The RBM refers to the commonly used approach where the conservation organization ranks the potential projects from highest to lowest based on the parcel's total benefits. Based on this ranking, the conservation organization seeks to acquire the top ranking parcels until the available budget is exhausted. Consequently, the set of parcels that is acquired consists of the highest ranking parcels available. This approach can lead to inefficient results from both an economic and agricultural preservation perspective, since the project's price is never explicitly factored into the decision process.

DALPF Program Model (DALPF)

DALPF historically has defined a project's benefits purely on the price for the easement offered by the landowner. DALPF uses an auction-type system that seeks to minimize costs by selecting projects based solely on the percent discount for the easement value that is offered by the landowner. In general the process works as follows. For each funding period (referred to as a "cycle"), DALPF offers all landowners in Agricultural Preservation Districts free appraisals if they express an interest in potentially selling their development rights. When the landowners receive the appraisal, they decide whether to continue with the process and, if so, what percentage of a discount on the non-agricultural value of the property (easement value) to offer to DALPF. Upon receiving all of the landowners' offers, DALPF purchases the projects with the highest percent discounts until the budget for that particular cycle is exhausted. Finally, the selected lands are then surveyed and the landowner receives final payment based on the percent discount offered and

the survey results. This auction-type system can be characterized as a "receive-what-you-offer" auction (also referred to as a "discriminative auction") since it pays different landowners different amounts based on the landowners' individual percent discount offers submitted.

In its essence, the DALPF model is a variant of the RBM as it first ranks the percent discounts from highest to lowest and then purchases the projects with the highest ranking discounts until the budget for the given cycle is exhausted. An advantage of this system is that by making the element of cost the sole benefit, DALPF does secure the farm land with the highest possible easement value given the budget constraint. However, unless the highest quality lands also are the ones with the greatest percent discounts, this system does not guarantee that the protected projects are high-quality farmlands or that other ancillary benefits are obtained for the core Green Infrastructure. Selecting projects solely based the percent discount offered can be compared to a grocery shopper who just buys food based on what items are *most* on sale. While this approach may work reasonably well in some settings, it does not guarantee that the set of selected foods is optimal. For example, the foods that are most on sale could be the least desirable (such as Spam or Ramen noodles). Likewise problems can arise if the foods that are most on sale are also those that are most expensive (such as caviar or truffles) which, even when significantly discounted, may still be relatively more expensive than other high quality, lower discounted foods. Both scenarios are feasible in the context of agricultural preservation. Low quality farms may view DALPF as the sole buyer willing to purchase otherwise marginal agricultural lands. Alternatively, the appraised values of farms near urban areas may be inflated due to real estate speculation and DALPF would therefore be acquiring lands that, even when discounted, are more expensive than similar farms not facing the same over-inflation in prices.

Optimization Model (OM)

The OM uses the same benefit information as the RBM, but in addition specifically accounts for the cost of each potential purchase and seeks to identify the most cost-effective solution. Thus, instead of seeking to identify the individual parcels with the highest benefits, the OM considers all possible combinations of parcels given a

Photo: The Conservation Fund/Blaine Phillips

budget constraint and selects the set of acquisitions that guarantees the maximum possible total benefits. To consider the vast number of possible combinations, the OM is a computer-driven process that uses binary linear programming. Fortunately, given today's computer power, these calculations can be done within seconds using an upgraded version of the Solver software program which is integrated into Microsoft Excel™. An advantage of the OM is that it can easily incorporate multiple constraints, such as different budget levels, minimum acreage goals, or a maximum number of acquisitions. The OM results also can be linked to a GIS mapping system to help visualize the implications of different OM scenarios.

As demonstrated in applied research, in cooperation with the Maryland Department of Natural Resources, which focused on the Catoctin Mountains in central Maryland, the OM can offer significantly higher benefits and greater cost effectiveness than the traditional rank based model (Messer, *Journal of Environmental Management* 2006, Messer and Wolf, *Exchange* 2004). The cost efficient set of development rights purchases generated by the OM can allow DALPF and other Delaware conservation partners the opportunity to maximize financial resources, provide economic rationale for purchase selections, and justify specific acquisition funding levels to achieve program goals.

DALPF historical analysis

This analysis evaluates the efficiency of DALPF's selection process by comparing its historical results with estimations of what the OM and RBM could have done given the same budget and the same set of potential projects to acquire. This analysis considers data, generously provided by DALPF, related to 524 projects. All of these projects were located in a designated Agricultural Preservation District and had applied for a free appraisal (a necessary precursor to selling the development rights to DALPF). Of the 524 projects, 509 (or 97%) were used in this analysis. The other 15 projects had significant data problems, such as lacking appraisal values, multiple records for the same project in the same cycle, or the total appraised acres reported did not correspond closely with the reported total of the appraised acres of farmland, forest, and wetland. The use of this subset of 509 parcels allowed for direct efficiency comparisons between the DALPF model and both the RBM and the OM. Note that since this subset of data was used, the results of this report may vary slightly from the numbers publicly reported by DALPF.

In its first nine completed cycles, DALPF purchased the development rights on 382 of these 509 projects (75%). Since DALPF did not record the offers of parcels that were not selected for development right acquisitions, this analysis assumes that these non-selected parcels would have had a percent discount that was on average 5% *less* than the *lowest* discount offer that DALPF purchased in that particular cycle.

This assumption of 5% is based on experience in working with the dataset and

expert judgment. Thus, the estimated percent discount for these 127 non-selected parcels averaged 34%, which was lower than the average discount accepted by DALPF of 45%.

Unfortunately, the available dataset was not able to distinguish between the landowners who did not sell because the percent discount they offered to DALPF was too low and the landowners who withdrew from the auction process and only initially acted as if they might sell in order to receive the free appraisal offered by DALPF. To account for this situation, the DALPF acquisitions were re-estimated using the entire set of 509 parcels where the budget constraint of $92,950,000 was used. Thus, all three techniques considered the same data sample of 509 parcels in the hypothetical situation that all were simultaneous in one cycle with a large budget, so that direct "apples-to-apples" comparisons could be reliably made. As can be seen in Table 1, the results of the DALPF "actual" and the DALPF "estimated" are nearly identical with respect to cost, easement value, number of parcels, acres, Land Evaluation and Site Assessment scores (LESA), and Core Green Infrastructure (CoreGI) values. These totals differed at most by 1%. Therefore, this hypothetical situation with just one large cycle seems to yield results that are similar to the actual nine separate cycles.

All measures, other than the number of acres, were scaled by the size of the parcel. For example, the LESA score was scaled by multiplying the original parcel-specific LESA score with a normalized measure of the number of acres to ensure that the final aggregate LESA scores could be meaningfully compared across scenarios. This scaling was necessary to ensure that if two neighboring 50-acre parcels with LESA scores of 90 each were acquired that this would be considered mathematically equal to the acquisition of one 100 acre parcel with a LESA score of 90. Without scaling, acquiring the two parcels would have yielded an aggregate LESA score of 180.

TABLE 1: DALPF HISTORICAL ANALYSIS — $92,950,000 BUDGET

BENEFIT SCENARIO	MODEL	COST	EASEMENT VALUE	PARCELS	LESA	CORE GI	ACRES
DALPF	Actual	$ 92,723,651	$ 158,875,490	382	4,404	1,639	67,834
DALPF	Estimated	$ 92,949,565	$ 159,359,569	386	4,281	1,615	67,002
Acres	OM	$ 92,936,382	$ 158,441,699	448	5,110	1,866	79,237
Acres	RBM	$ 92,949,727	$ 101,505,054	224	2,552	890	39,987
Acres & LESA	OM	$ 92,937,301	$ 158,855,984	454	5,108	1,883	78,956
Acres & LESA	RBM	$ 92,949,149	$ 102,947,233	230	2,614	936	40,862
Acres, LESA & CoreGI	OM	$ 92,945,105	$ 158,943,991	453	5,122	1,893	79,178
Acres, LESA & CoreGI	RBM	$ 92,949,306	$ 110,456,201	237	2,742	956	42,852
TOTAL POSSIBLE		$ 127,699,959	$ 213,190,562	509	5,625	2,069	87,407

Table 1 shows the results of three different "benefit scenarios" for both the OM and RBM at that budget level of $92,950,000 for all 509 parcels. The first scenario defined benefits as only the number of acres. The second scenario defined benefits as the number of acres and the LESA score, where both variables were weighted equally. The third analysis defined benefits as the number of acres, LESA value, and CoreGI, and all three variables were weighted equally. Upon inspection of Table 1, for each model, the differences between the three scenarios are generally small. For example, the number of acres differed by less than 0.1% in the three OM scenarios. Therefore, this discussion will focus on the results of the third scenario, which most closely resembles the weights that resulted from the feedback received at the Green Infrastructure Leadership Forum meeting.

The results of the third scenario reveal a consistent trend. The DALPF model produces aggregate results that are significantly better than the RBM but are worse than the aggregate benefits offered by the OM. For example, the DALPF model would acquire 67,834 acres, the RBM would acquire 42,852 acres, and the OM would acquire 79,178 acres. Thus, DALPF would secure 24,150 more acres than the RBM, an improvement of 36.0%. However, the total from the DALPF model is 12,176 acres short of the total achieved by the OM, a decrease of 18.2%. Similarly, the DALPF model achieves higher scores than the RBM for both aggregate LESA (35.9% more) and CoreGI (40.8% more), but 19.7% and 18.2% less than the OM, respectively (Table 1).

The only variable where DALPF yields higher aggregate values than the OM is Easement Values. In this case, the DALPF model had aggregate scores that are 0.2% higher than the OM. This outcome is as expected since the DALPF model gives sole priority to the percent discount offered by the landowner, and thus, maximizes the possible Easement Value. Note that if the sole benefit used in the OM was Easement Value, instead of the number of acres, LESA, and CoreGI, then the results between the DALPF model and the OM would have been identical. However, this 0.2% gain in total Easement Value is unlikely to be worth more than the additional 12,000 acres and nearly 20% improvements in the total LESA and the CoreGI scores that are achieved by the OM.

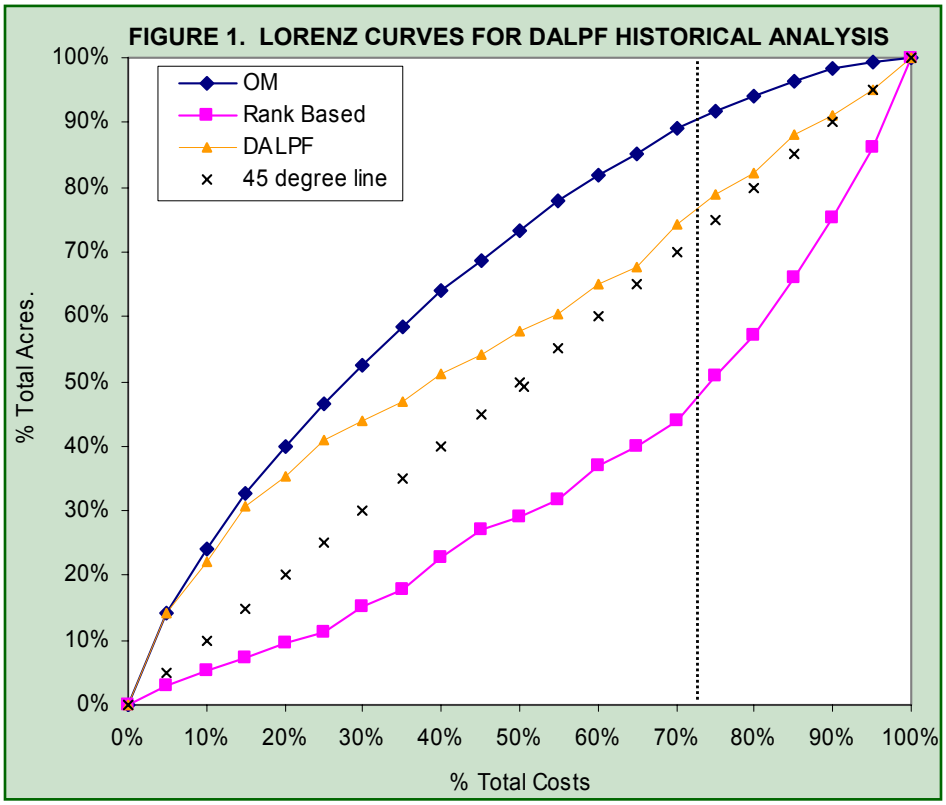
Photo: Jo Gravely

Measuring Efficiency: Lorenz Curves

The differences in efficiency can be seen graphically by examining the Lorenz curve depicted in Figure 1 that shows the results of the third scenario for the OM and RBM and the estimated DALPF model. The horizontal axis depicts the percentage of costs from the total possible of $128 million and the vertical axis represents the percentage of acres from the total possible of 87,407 acres (Table 1). The three curves start at the same point where 0% of the costs have been incurred (no parcels protected) and then meet again when 100% of the costs have been incurred (all parcels protected). The 45 degree line denotes the situation where the cost percentage equals the benefit percentage (i.e. 30% of the total costs equals the 30% of the total acres). Comparing the curves provides an estimate of efficiency as the curve that is highest on the vertical axis is the most efficient and the larger the space between curves the larger the efficiency difference.

Each model was run 20 times to determine the set of acquisitions given 5% budget intervals. As can be seen, both the OM and the DALPF curves are always above the 45 degree line. These two curves start out as nearly identical, but then divert starting at 15% of the costs. By 55% of the costs, the DALPF curve parallels the 45 degree line. In contrast, the OM curve maintains its high trajectory. The RBM starts off below the 45 degree line and generally drops further below until nearly 80% of the total costs, at which point it begins to move closer to the 45 degree line.

At a given budget point, the space between the lines also provides a measure of the efficiency differences. In the scenarios discussed earlier, a budget of $92,950,000 is 73% of the total possible cost of $128 million. As can be seen in this figure, at 75% of costs the OM yields 92% of the total acres, DALPF yields 79% of the total acres, and the RBM yields just 51% of the total acres. A formal measure of efficiency is the Gini coefficient which is calculated as the area between the curve and the 45 degree line, where the greater the number, the greater the efficiency. Based on calculations using 21 trapezoids for the data displayed in Figure 1, the Gini coefficients were 0.169 for the OM, 0.075, and -0.157 for the RBM.



Cycle Analysis

The trends observed in the situation where all 509 parcels are considered simultaneously are also evident when specific funding cycles are evaluated. To date, DALPF has complete nine cycles, roughly one per year. In these situations, the results of the OM and the RBM can be compared to DALPF's actual acquisitions given the set of potential sellers. Evaluation of these cycle analyses shows that in several cycles DALPF acquired nearly all of the available projects (Tables 8.1 – 8.9). In these cases, the difference in results between the three selection techniques is minimal. However, in situations where the number of potential sellers significantly exceeds the available funds, then the efficiency difference is evident.

For example, Cycle 6 illustrates the major factors that led to the efficiency difference. In this cycle that ended in 2000, 80 landowners applied for appraisals and 34 were finally selected at a cost of $5,636,505 (Table 2). These acquisitions represented just 27.7% of the total estimated costs of $20,343,424 for all 80 parcels. For a budget of $5,650,000 and the third scenario where the benefits of the number of acres, LESA, and CoreGI were weighted equally, the OM would conserve 8,050 acres in contrast to 6,426 acres actually conserved by DALPF and 2,929 acres that would have been conserved using a RBM approach. A primary reason for RBM's inefficiency is the presence of one or more "budget sponges" that both rank high with regards to benefits, but also are very expensive. In this case, the easement for one project cost over $2.7 million dollars and had nearly 1,100 acres. While the average per acre cost of $2,561 does not seem too high relative to the actual market prices, it is more than three times higher than the $701 that was the average per acre cost of the 39 parcels selected by the OM and the $877 per acre for the 34 parcels selected by DALPF.

TABLE 2: DALPF CYCLE 6 RESULTS — $5,650,000 BUDGET

BENEFIT SCENARIO	MODEL	COST	EASEMENT VALUE	PARCELS	LESA	CORE GI	ACRES
DALPF	Actual	$ 5,636,505	$ 11,572,773	34	410	204	6,426
Acres	OM	$ 5,649,428	$ 10,625,921	40	515	248	8,134
Acres	RBM	$ 5,648,412	$ 8,331,210	13	207	96	3,307
Acres & LESA	OM	$ 5,646,662	$ 10,735,604	43	514	248	8,067
Acres & LESA	RBM	$ 5,648,412	$ 8,331,210	13	207	96	3,307
Acres, LESA & CORE GI	OM	$ 5,644,815	$ 10,701,899	39	516	256	8,050
Acres, LESA & CORE GI	RBM	$ 5,645,852	$ 8,156,306	12	188	70	2,929
TOTAL POSSIBLE		$ 20,343,424	$ 35,682,471	80	861	355	13,679

Potential Savings

Another means for evaluating efficiencies is to estimate the cost difference between the sets of acquisitions that each model produced. Using the entire set of 509 projects described previously, the potential savings of using the OM was calculated. Recall that the DALPF model would have acquired an estimated 386 parcels for a total cost of $92,949,565. This set of acquisitions would have yielded 67,002 acres and have aggregate scores of 4,281 for LESA and 1,615 for CoreGI (Table 3). The OM was then set to find the set of acquisitions that minimized expenditures while still achieving the same level of aggregate benefits as DALPF. When all three benefits were considered, the OM purchased 371 parcels at a cost of just $68,012,385. This selected set would have totaled 67,004 acres and have aggregate scores of 4,317 for LESA and 1,616 for CoreGI. In other words, the OM would have found a set of acquisitions that would yield equivalent scores for all three benefit measures (numbers of acres, LESA, and CoreGI) at a cost that was nearly $25 million less that the DALPF model. Similar calculations were made where the desired benefits were defined as only one variable (Acres, LESA or CoreGI). In these scenarios, the potential costs savings for using the OM instead of the DALPF model ranged from $25 million to $33.5 million (Table 3).

Calculations were made to determine the amount of additional expense required for the DALPF model to achieve equivalent aggregate values for the three benefits (Acres, LESA, and CoreGI) as the OM achieved for the $92.7 million budget scenario. From this perspective, it would have cost DALPF a total of $113.5 million to achieve equivalent scores as the OM – an additional expense of $20.5 million (Table 3).

TABLE 3: COST SAVINGS & EXTRA EXPENSE ESTIMATES FOR THE OM & DALPF

BENEFIT SCENARIO	MODEL	COST	EASEMENT VALUE	PARCELS	LESA	CORE GI	ACRES	SAVINGS
DALPF	**Estimated**	$ 92,949,565	$ 159,359,569	386	*4,281*	*1,615*	*67,002*	
Acres	**OM**	$ 67,960,181	$ 118,658,131	374	4,313	1,606	*67,003*	**$(24,989,384)**
LESA	**OM**	$ 66,533,893	$ 117,026,987	365	*4,281*	1,583	65,861	**$(26,415,672)**
CoreGI	**OM**	$ 59,423,919	$ 100,925,410	279	3,616	*1,615*	55,842	**$(33,525,646)**
Acres, LESA & CoreGI	**OM**	$ 68,012,385	$ 119,205,316	371	*4,317*	*1,616*	*67,004*	**$(24,937,180)**
BENEFIT SCENARIO	**MODEL**	**COST**	**EASEMENT VALUE**	**PARCELS**	**LESA**	**CORE GI**	**ACRES**	**SAVINGS**
DALPF	**Estimated**	$ 92,949,565	$ 159,359,569	386	*4,281*	*1,615*	*67,002*	
Acres	**OM**	$ 67,960,181	$ 118,658,131	374	4,313	1,606	*67,003*	**$(24,989,384)**

TABLE 4: SUMMARY STATISTICS OF THE 1,095 UNPROTECTED AGRICULTURAL PARCELS IN KENT COUNTY				
VARIABLE	Total	Average	Minimum	Maximum
Number of Acres	96,271	87.9	1.5	853.7
LE Score	8,105	7.4	0.1	83.9
SA Score	6,875	6.3	0.1	72.1
LESA Score	7,285	6.7	0.1	76.1
Core GI	2,390	2.2	0.0	43.0
Farm Suitability	5,588	5.1	0.1	64.0
Lower-Bound Cost Estimate	$ 173,103,359	$ 158,085	$ 35,621	$ 1,839,034
Upper-Bound Cost Estimate	$ 438,188,025	$ 400,172	$ 90,169	$ 4,655,270

Achieving the Livable Delaware Goal

The second analysis evaluated what would be needed to achieve the *Livable Delaware* goal of protecting 50% of the remaining agricultural land by 2024. Since the majority of the remaining agricultural land in Delaware is in Kent County, the goal of protecting an additional 60,000 acres in Kent County over the next 18 years was evaluated. The analysis identified 1,095 unprotected parcels that had more than 20 tillable acres. All of these parcels were in State Investment Level 4 and 227 parcels were in an existing Agricultural Preservation District. The 1,095 parcels totaled 96,271 acres and the average size was 87.9 acres (Table 4).

Hedonic Model Development

A critical element to this analysis was accurate easement cost estimates for each of the 1,095 parcels. While the historic DALPF analysis used actual appraisals for these costs, reliable cost data, even reliable tax assessor records, was not available in Delaware. Therefore, the easement costs were estimated with a hedonic model which used as a base the DALPF appraisal information. A hedonic analysis uses the regression statistical technique to identify the individual affect of different independent variables (such as number of acres, soil type, and year of appraisal) on the dependent variable (easement value). An advantage of a hedonic analysis is that the estimated coefficients for the statistically significant independent variables can be used to estimate easement costs for parcels that have not been formally appraised. In other words, the data from the 500+ parcels that have been collected over the past decade for the entire state of Delaware can be used to estimate the easement values for the 1,095 unprotected parcels in Kent County.

Table 5 shows the 22 variables used in the hedonic model that estimated a natural log transformation of easement prices. Transforming the dependent variable is standard practice in hedonic analysis and generally improves the accuracy of the estimates. The model used a sample of 501 parcels from the nine completed cycles. In

TABLE 5: VARIABLES USED IN HEDONIC MODEL

VARIABLE	COEFFICIENT	INTERPRETATION	
KENT	12.053***	+ $171,613.48	Constant for Kent County
NEW_CASTLE	12.528***	+ $275,956.91	Constant for New Castle County
SUSSEX	12.258***	+ $210,659.84	Constant for Sussex County
ACRES	0.009***	+ $3,318.48	Increase per acre
ACRES^2	-6.13E-6***	- $2.26	Value increases at a decreasing rate when the number of acres increases
CYCLE	-0.073*	- $26,916.58	Value decreases per each cycle
CYCLE^2	0.014***	+ $5,162.08	Value increases rapidly as cycles increase (Note: the affect of this increase surpasses in magnitude the per cycle decline by the third cycle and continues to grow beyond that)
LESA	-0.009***	- $3,318.48	Decrease per additional point in the LESA score
AG_PROGRAM	-0.132**	- $48,671.07	Decrease if part of the land is enrolled in Conservation Reserve Program (CRP) or Conservation Reserve Enhancement Program (CREP)
HAS_SEWER	-0.011**	-$4,055.92	Decrease if not connected to the sewer system (or planned sewer system) as each score from the LESA system increases
NAT_RES	0.010	-	Insignificant
NAT_RES^2	0.000	-	Insignificant
CORE_GI	0.007	-	Insignificant
CORE_GI^2	0.000	-	Insignificant
DIST_PROTECTED	-3.83E-5	-	Insignificant
DIST_PROTECTED^2	1.78E-8	-	Insignificant
DIST_HIGHWAY	-1.34E-5	-	Insignificant
DIST_HIGHWAY^2	2.74E-9	-	Insignificant
DIST_SHORE	-1.71E-5**	- $6.31	Decrease for each mile away from the shore
DIST_SHORE^2	-2.21E-11	-	Insignificant
DIST_URBAN	-7.44E-5***	- $27.43	Decrease for each mile away from the nearest urban area
DIST_URBAN^2			Insignificant
N	501		
R^2	0.999		

Notes: *** indicates significance at the 1% level,
** indicates significance at the 5% level, * indicates significance at the 10% level.

addition to the restrictions already discussed, observations were removed if they had applied to DALPF in more than one cycle, but only had received one appraisal and if the per acre easement value was more than two standard deviations above the sample mean (for example, one parcel had an easement value of $30,000 per acre). The squares of several variables were included in the model to evaluate how easement value changed as the variable grew increasingly large.

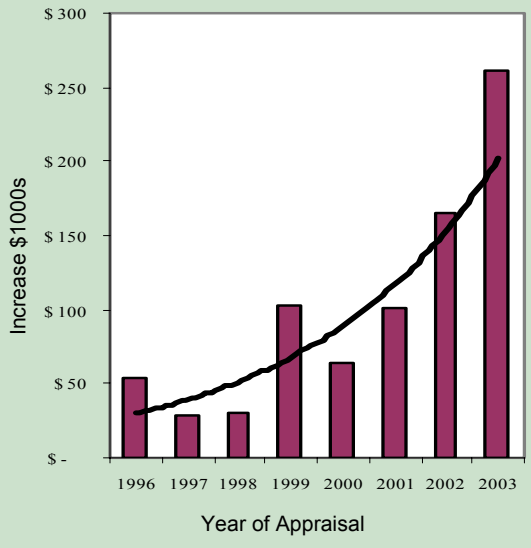
Given the size of the dataset and the richness of the explanatory variables, the hedonic model captures almost all of the observed variability in the easement value (Table 5). Inspection of the signs of the coefficients for the variables reveals three statistically significant constants depending upon the county location of the parcel. Additionally, two variables had significant positive affects on the easement value (ACRES and CYCLE2), and seven variables had significant negative affects (ACRES2, CYCLE, LESA, AG_PROGRAM, HAS_SEWER, DIST_SHORE, and DIST_URBAN). Eleven of these twelve variables had p-values that were less than 0.05, the standard cut-off indicating whether a variable is statistically significant. The other variable had a p-value of 0.064 indicating marginal significance. The coefficients for the variables can be interpreted by multiplying them by the mean easement value of the original dataset ($368,720). For example, an increase of one acre increases the estimated easement value by $3,318 (0.009 x $368,720). The three county dummy variables can be interpreted by taking the antilog of the variable. For Kent County, the constant easement value was $171,613 (e^12.053). The coefficients and a brief interpretation for each statistically significant variable are provided in Table 5.

Calculating Easement Costs with a Hedonic Analysis

Based on this hedonic model, a lower-bound estimate can be calculated for the full easement costs for each of the 1,095 parcels in 2006 dollars. This amount was then discounted by the historic percentage discount received by DALPF of 45%. Thus, the total easement cost for all 1,095 parcels is estimated at $173,103,359 with an average easement costing $158,085 and the average acre costing $1,798 (Table 4).

Determining an upper-bound estimate of the easement costs is difficult. The primary difficulty is that the real estate values in Delaware have been rapidly accelerating the past decade. Evidence of this increase can be found both in the hedonic model discussed above (the large, positive coefficient on CYCLE2) and also in a second hedonic model that included yearly dummy variables (1996, 1997, and so forth) (Table 8.9). Figure 2 displays the estimated coefficients for each of the yearly dummy variables of this second hedonic model, and a trend line provides an estimate of the acceleration of the easement values.

FIGURE 2. INCREASE IN APPRAISED VALUE OF EASEMENTS SINCE 1995.



A second reason why the 2006 estimates should be considered as lower-bound is that over the next 18 years, landowners may offer lower percent discounts than the historic average of 45%. In other words, in the first decade DALPF may have harvested the "low hanging fruit" from landowners who were willing to accept compensations that were roughly half of the appraised market value. In the next 18 years of activity, DALPF may face landowners who are more reluctant to offer high discounts for their easements. Given the potential for easement values to increase either through continued property value increases or lower percent discounts offered by landowners, this analysis used the hedonic model to calculate an upper-bound estimate where the 1,095 parcel cost a total of $438,188.025, roughly 150% higher than the lower-bound. For the upper-bound estimate, the average easement cost is $400,172 and the average per acre easement cost is $4,551 (Table 4).

Photo: The Conservation Fund/Ted Weber

Minimum Expenditures to Protect 60,000 Acres in Kent County

This analysis first sought to determine the minimum budget needed by the OM and the RBM to secure an additional 60,000 acres given the lower- and upper-bound easement cost estimates. In these minimum budget scenarios, the only benefit that received any weight was the number of acres. As can be seen in Table 6, the minimum budget that the OM would need to achieve the 60,000 acre goal ranged from $4.6 million annually in the lower-bound estimates to $11.6 million annually in the upper-bound estimates. In contrast, the RBM would need $6.8 million and $17.3 million annually to achieve the 60,000 acre goal, respectively. Thus, the use of the OM relative to the RBM would have potentially saved between $2.2 million and $5.7 million annually.

The second step was to assume that the desired benefits of these acquisitions should extend beyond just the number of acres preserved, but also to include some measures for the quality of farmland preserved and the ancillary benefits provided to the Green Infrastructure. Therefore, the analysis used the weighting priorities that were derived from the feedback received at the Green Infrastructure Leadership Forum meeting described previously. Thus, "farm suitability" was defined by three factors — the LE, SA, and Core GI scores — where the weights were 12%, 56%, and 32%, respectively. These measures were scaled based on the size of the parcel, as described earlier. To

achieve greater levels of these farm suitability aspects, an additional budget level was selected that was $10 million greater over the life of the program than the minimum amount required by the OM to protect 60,000 acres. For the lower-bound estimate, a budget level of $5.1 million per year was evaluated and, for the upper-bound estimate, a budget level of $12.2 million was evaluated (Table 6). In all of these analyses, both farm suitability and number of acres were weighted equally, and a constraint was set that the model must still achieve the 60,000 acre goal. The results show that the additional money did yield higher numbers of acres preserved along with higher aggregate scores with regards to LESA, CoreGI and thus Farm Suitability (Table 6). Note that even with an additional $10 million, the RBM was still more than 17,000 acres short of the 60,000 acre goal.

Photo: Jo Gravely

The differences in efficiency between the OM and the RBM are readily evident in these analyses of Kent County. Table 7 shows the vast differences between the two models when the budgets are set at the minimum levels necessary to achieve the 60,000 acre goal. When the budget was set at $4.6 million per year and the lower-bound cost estimates were used, the OM secured 60,000 acres, while the RBM secured only

TABLE 6: RESULTS FOR THE KENT COUNTY ANALYSIS

BENEFIT SCENARIO	MODEL	COST ESTIMATE	ANNUAL COST	ACRES	PARCEL	LESA	CORE GI	FARM SUITABILITY
Acres	OM	Lower-Bound	$ 4.6 million	60,000	517	4,568	1,513	3,527
Acres	OM	Upper-Bound	$ 11.6 million	60,000	516	4,568	1,513	3,527
Acres	RBM	Lower-Bound	$ 6.8 million	60,069	566	4,647	1,539	3,567
Acres	RBM	Upper-Bound	$ 17.3 million	60,393	572	4,671	1,547	3,585
Acres, LE, SA & CoreGI	OM	Lower-Bound	$ 5.1 million	64,985	549	5,017	1,684	3,879
Acres, LE, SA & CoreGI	OM	Upper-Bound	$ 12.2 million	61,923	521	4,778	1,618	3,699
Acres, LE, SA & CoreGI	RBM	Lower-Bound	$ 5.1 million	42,782	345	3,368	1,130	2,587
Acres, LE, SA & CoreGI	RBM	Upper-Bound	$ 12.2 million	39,242	304	3,110	1,053	2,391
TOTAL POSSIBLE				96,271	1,095	7,285	2,390	5,588

37,180, a difference of 22,820 acres (38.0% lower). Similarly, the LESA, CoreGI, and Farm Suitability scores are 35.5%, 34.1% and 35.8% lower, respectively, with the RBM. When the budget was set at $6.8 million per year, the RBM was able to achieve the 60,000 acres goal, but for the same money, the OM could have potentially secured nearly 19,000 additional acres (Table 7). Analysis with the upper-bound cost estimates yielded the same trends.

Photo: The Conservation Fund/Ted Weber

TABLE 7: EFFICIENCY COMPARISONS BETWEEN THE OM & THE RBM FOR KENT COUNTY

BENEFIT SCENARIO	MODEL	COST ESTIMATE	ANNUAL COST	ACRES	PARCEL	LESA	CORE GI	FARM SUITABILITY
Budget $4.6 million per year								
Acres	OM	Lower-Bound	$ 4.6 million	60,000	517	4,568	1,513	3,527
Acres	RBM	Lower-Bound	$ 4.6 million	37,180	280	2,947	997	2,266
Budget $6.8 million per year								
Acres	RBM	Lower-Bound	$ 6.8 million	60,069	566	4,647	1,539	3,567
Acres	OM	Lower-Bound	$ 6.8 million	79,025	715	6,049	1,999	4,653

policy and funding recommendations

Based on the results of the historical analysis of DALPF and the analysis of the available land in Kent County, three policy recommendations and one funding recommendation are offered. First, the historic analysis reveals that the DALPF structure already has a number of positive characteristics, such as a competitive auction structure and free appraisals to increase the number of potential sellers. The DALPF model yields aggregate results that consistently exceed those from the RBM that is commonly used in conservation settings. However, DALPF has considerably more efficiency to gain by incorporating the OM into its existing structure. For example, if the OM had been available to DALPF in the past decade, up to an additional 12,000 acres could have been protected for the same cost. An alternative way of viewing this efficiency gain is that the OM would have enabled DALPF to achieve the same level of aggregate benefits for between $25 and $33.5 million less.

To retain a high level of transparency in its current auction system, DALPF may want to consider Cost Effective Analysis, an economic technique that yields results similar to the OM. While Cost Effective Analysis cannot guarantee optimality like the OM, in most situations it yields near optimum aggregate results and will certainly yield substantial benefits over the current DALPF model. Cost Effective Analysis operates by evaluating the benefit-cost ratio of each parcel and purchasing the parcels with the highest ranking ratios until the available budget is exhausted. A potential advantage of Cost Effective Analysis is its greater transparency, which may be appealing from a policy implementation perspective.

A second policy recommendation is that DALPF should consider alternative designs for its auction mechanism to become more incentive compatible. A key element to achieving the *Livable Delaware* objectives is keeping the average percent discount rate as high as possible. As discussed earlier, DALPF currently uses a discriminative auction structure (the landowner receives the sales price based on the percent discount offered). While this structure has intuitive appeal, it has been known to engender price inflation in multiple-round settings, since sellers have an incentive to inflate their offers above their true willingness to sell. Furthermore, the value of the lowest accepted offer from the previous cycle tends to establish a focal point that can discourage higher percent discount offers in future rounds. Since the average percent discount currently is 45%, it appears that sellers to DALPF have been motivated by other factors than just simple profit maximization. However, over time this trend may change, and thus, DALPF may want to explore the ability of alternative auction designs to ensure high percent discount offers. A cost-effective environment for testing alternative auction designs is an experimental economics laboratory.

Based on both the DALPF history and analysis of the 60,000 acre goal for Kent County, a third policy recommendation is that other conservation efforts in Delaware should use the OM and not the RBM. The level of efficiencies observed here within the context of agricultural lands will also be

true for other conservation contexts. In particular, these findings are relevant to the forthcoming Delaware Forestland Preservation Program, which was created in July 2005.

The final question addressed in this report is what level of funding is appropriate to achieve the *Livable Delaware* objective to 60,000 acres for Kent County. To reach this goal, an average of 3,333 acres will need to be protected each year for eighteen years. As a point of reference, during DALPF's tenure expenditures averaged $10 million per year and it protected an average of 6,783 acres per year throughout the State.

Table 8: CYCLE BY CYCLE RESULTS

Table 8.1 - Cycle 1 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	10,162,050	14,038,444	27	475	181	7,397
Estimated Budget	*10,250,000*					
Acres, LESA, CoreGI - OM	10,220,211	14,073,165	26	479	184	7,514
Acres, LESA, CoreGI - RBM	10,190,237	14,043,388	25	481	183	7,542
TOTAL POSSIBLE	10,416,973	14,329,326	28	488	186	7,656

Table 8.2 - Cycle 2 Results

	Cost	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	5,302,913	11,434,654	31	352	114	5,337
Estimated Budget	*5,300,000*					
Acres, LESA, CoreGI - OM	5,280,611	11,393,317	31	351	114	5,318
Acres, LESA, CoreGI - RBM	5,280,611	11,059,479	31	334	109	5,045
TOTAL POSSIBLE	5,327,272	11,465,103	32	354	114	5,362

Table 8.3 - Cycle 3 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	10,784,917	14,774,096	30	466	226	6,940
Estimated Budget	*10,750,000*					
Acres, LESA, CoreGI - OM	10,741,016	14,580,118	38	501	238	7,656
Acres, LESA, CoreGI - RBM	10,745,725	9,182,928	23	250	115	3,849
TOTAL POSSIBLE	13,198,117	17,790,595	42			8,512

For Kent County, in the first nine cycles, DALPF has spent a total of $44,643,147 (approximately $4.7 million per year) and acquired 37,007 acres (4,112 acres per year). However, DALPF protected many of these acres during times when the easement values were considerably lower than even the lower-bound estimate used in this analysis. Therefore, current expenditure levels will only be successful in reaching the goal if the OM model is used, real estate values do not continue to grow at a rapid pace, and landowners continue to offer percentage discounts near 45-50%. If all of these assumptions are not met, an increase in funding will be needed. Otherwise, if the RBM approach is used to achieve the 60,000 acres, it will cost $6.7 to $17.4 million

Table 8.4 - Cycle 4 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	22,941,840	32,598,414	53	794	267	11,668
Estimated Budget	*22,950,000*					
Acres, LESA, CoreGI - OM	22,884,820	32,784,395	64	965	285	12,792
Acres, LESA, CoreGI - RBM	22,945,009	25,793,794	44	613	193	9,180
TOTAL POSSIBLE	25,671,965	36,673,228	65	896	294	13,272

Table 8.5 - Cycle 5 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	13,757,131	28,375,026	78	976	324	15,350
Estimated Budget	*13,750,000*					
Acres, LESA, CoreGI - OM	13,749,548	28,202,501	77	985	326	15,491
Acres, LESA, CoreGI - RBM	13,737,737	20,538,013	58	693	227	10,830
TOTAL POSSIBLE	15,595,328	31,247,209	83	1,018	337	16,008

Table 8.6 - Cycle 6 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	5,636,505	11,572,773	34	406	202	6,426
Estimated Budget	*5,650,000*					
Acres, LESA, CoreGI - OM	5,644,815	10,701,899	39	511	253	8,050
Acres, LESA, CoreGI - RBM	5,645,852	8,156,306	12	186	70	2,929
TOTAL POSSIBLE	20,343,424	35,682,471	80	853	352	13,679

annually. In contrast, if the OM approach is used, the annual cost will be $4.5 to $11.6 million. Based on the results of these analyses, this report recommends budgeting $8 million per year for agricultural land preservation in Kent County. If the RBM or DALPF model is used, the amount budgeted should be $11 to $12 million annually.

Table 8.7 - Cycle 7 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	5,661,850	12,170,868	32	276	95	4,192
Estimated Budget	*5,675,000*					
Acres, LESA, CoreGI - OM	5,667,047	11,157,910	36	401	129	5,992
Acres, LESA, CoreGI - RBM	5,670,899	7,847,347	7	149	74	2,345
TOTAL POSSIBLE	12,412,646	23,612,895	55	569	209	8,635

Table 8.8 - Cycle 8 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	6,662,322	13,687,588	42	318	110	5,059
Estimated Budget	*6,700,000*					
Acres, LESA, CoreGI - OM	6,691,135	12,186,778	45	416	145	6,450
Acres, LESA, CoreGI - RBM	6,697,012	9,538,250	27	255	93	4,146
TOTAL POSSIBLE	12,631,058	21,645,900	66	534	184	8,494

Table 8.9 - Cycle 9 Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	11,814,123	20,223,627	55	341	119	5,467
Estimated Budget	*11,850,000*					
Acres, LESA, CoreGI - OM	11,165,627	18,559,157	55	355	134	5,656
Acres, LESA, CoreGI - RBM	1,117,252	18,903,580	47	339	128	5,430
TOTAL POSSIBLE	12,314,331	20,723,835	58	361	135	5,791

Table 8.10 - Total Cycle Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	92,723,651	158,875,490	382	4,404	1,639	67,834
Estimated Budget	*92,875,000*					
Acres, LESA, CoreGI - OM	92,044,830	153,639,240	411	4,964	1,807	74,919
Acres, LESA, CoreGI - RBM	82,030,334	125,063,085	274	3,299	1,190	51,296
TOTAL POSSIBLE	127,911,114	213,170,562	509	5,072	1,811	87,407

Table 8.11 - DDA_ALL Results

	Cost $	Easement Value $	Parcels	LESA	Core Green Infrastructure	Acres
DDA Actual Acquisitions	92,723,651	158,875,490	382	4,404	1,639	67,834
Estimated Budget	*92,950,000*					
Acres - OM	92,936,382	158,441,699	448	5,110	1,866	79,237
Acres - RBM	92,949,727	101,505,054	224	2,552	890	39,987
Acres, LESA - OM	92,937,301	158,855,984	454	5,108	1,883	78,956
Acres, LESA - RBM	92,949,149	102,947,233	230	2,614	936	40,862
Acres, LESA, CoreGI - OM	92,945,105	158,943,991	453	5,122	1,893	79,178
Acres, LESA, CoreGI - RBM	92,949,306	110,456,201	237	2,742	956	42,852
TOTAL POSSIBLE	127,699,959	213,190,562	509	5,625	2,069	87,407

TABLE 9: INTERPRETATION OF HEDONIC ANALYSIS RESULTS WITH ADDITIONAL VARIABLES, DEPENDENT VARIABLE, Ln (EASEMENT VALUE)			
VARIABLE	**COEFFICIENT**	**INTERPRETATION**	
KENT	11.968***	+ $157,629.09	Constant for Kent County
NEW_CASTLE	12.469***	+ $260,146.44	Constant for New Castle County
SUSSEX	12.171***	+ $193,107.05	Constant for Sussex County
TILL_ ACRES	0.008***	+ $2,949.76	Increase per tillable acre
TILL_ ACRES^2	-5.95E-6***	- $2.19	Value increases at a decreasing rate when the number of tillable acres increases
FOREST_ ACRES	0.010***	+ $3,687.20	Increase per forest acre
FOREST_ ACRES^2	-2.66E-5***	- $9.81	Value increases at a decreasing rate when the number of forest acres increases
WETLAND_ ACRES	0.004***	+ $1,474.88	Increase per wetland acre
WETLAND_ ACRES^2	-7.89E-6***	- $2.91	Value increases at a decreasing rate when the number of wetland acres increases
1996	0.148	-	Insignificant
1997	0.078	-	Insignificant
1998	0.081	-	Insignificant
1999	0.281***	+ $103,610.38	Increase relative to 1995
2000	0.173*	+ $63,788.60	Increase relative to 1995
2001	0.273**	+ $100,660.62	Increase relative to 1995
2002	0.448***	+ $165,186.65	Increase relative to 1995
2003	0.709***	+ $261,422.63	Increase relative to 1995
LESA	-0.009***	- $3,318.48	Decrease per additional point in the LESA score
AG_PROGRAM	-0.127**	- $46,827.47	Decrease if part of the land is enrolled in Conservation Reserve Program (CRP) or Conservation Reserve Enhancement Program (CREP)
HAS_SEWER	-0.010*	- $3,687.20	Decrease if not connected to the sewer system (or planned sewer system) as each score from the LESA system increases
NAT_RES	0.006	-	Insignificant
NAT_RES^2	-7.45E-5	-	Insignificant
CORE_GI	0.001	-	Insignificant
CORE_GI^2	-1.20E-5	-	Insignificant
DIST_PROTECTED	6.20E-5	-	Insignificant
DIST_PROTECTED^2	-1.48E-8	-	Insignificant
DIST_HIGHWAY	-1.70E-7	-	Insignificant
DIST_HIGHWAY^2	2.22E-9	-	Insignificant
DIST_SHORE	-2.08E-5	- $7.67	Decrease for each mile away from the shore
DIST_SHORE^2	2.49E-11	-	Insignificant
DIST_URBAN	-6.86E-5	- $25.29	Decrease for each mile away from the nearest urban area
DIST_URBAN^2	2.77E-9	-	Insignificant
N	501		
R^2	0.999		
Notes: *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.			

references

Green Infrastructure Planning

Amundsen III, Ole. “Implementing Strategic Conservation: Establishing Criteria”, *Exchange*, Summer 2004, Vol. 23. No. 3, pp.7-10. (http://www.ltanet.org/)

Benedict, Mark A. and Edward T. McMahon. *Green Infrastructure: Linking Landscapes and Communities*, 2006, Island Press. (http://www.islandpress.org)

Benedict, Mark A. and Edward T. McMahon. "Green Infrastructure: Smart Conservation for the 21st Century", *Renewable Resources Journal*, Autumn 2002, Vol. 20. No. 3, pp.12-17. (http://www.conservationfund.org/pdf/GI_RR.pdf)

Benedict, Mark A. and Edward T. McMahon. "Green Infrastructure: Smart Conservation for the 21st Century", *Sprawl Watch Clearinghouse*, May 2002, Monograph Series. (http://www.greeninfrastructure.net/pdf/sprawlwatch_gi.pdf)

McDonald, Leigh Anne, William L. Allen, III, Mark A. Benedict, and Keith O'Connor. "Green Infrastructure Plan Evaluation Frameworks", Journal of Conservation Planning, 2005, Vol. 1 No. 1. (http://www.journalconsplanning.org/2005/index.html)

Delaware State and Local Planning

Better Models for Development. (http://www.conservationfund.org/?article=3021)

Edgell, David L and D. Barrett Edwards. Equity in Agriculture: Preserving the Value of Delaware's Rural Lands, Delaware Office of State Planning Coordination, September 2005. (http://www.state.de.us/planning)

Kent County Department of Planning Services (http://www.co.kent.de.us/Departments/Planning/index.htm)

Livable Delaware Initiative. (http://www.state.de.us/planning/livedel/default.shtml)

State Strategies for Policy and Spending. (http://www.state.de.us/planning/strategies/strategies.shtml)

Analytic Hierarchy Process, Pairwise Comparisons, Suitability Analysis

Bennett and Williams Environmental Consultants, Inc. *Revised Land Evaluation and Site Assessment Model (LESA) for the State of Delaware*, July 2005.

Berry, Joseph. Map Analysis: Procedures and Applications in GIS Modeling, 2005, BASIS Press. (http://63.78.10.20/basis/MapAnalysis/Default.htm)

Duke, Joshua M. "Participation in Agricultural Land Preservation Programs: Parcel Quality and a Complex Policy Environment", *Agricultural and Resource Economics Review*, April 2004. (http://www.findarticles.com/p/articles/mi_qa4046/is_200404/ai_n9396961)

Duke, Joshua M. and Rhonda A. Hyde. "Identifying Public Preferences for Land Preservation Using the Analytic Hierarchy Process", *Ecological Economics*, Vol. 42, 2002, pp. 131-145. (http://www.elsevier.com/locate/ecolecon)

Duke, Joshua M., Thomas W. Ilvento, and Rhonda A. Hyde. "Public Support for Land Preservation: Measuring Relative Preferences in Delaware", *Food and Resource Economics*, February 2002.

Duke, Joshua M. and Thomas W. Ilvento. "A Conjoint Analysis of Public Preferences for Agricultural Land Preservation", *Agricultural and Resource Economics Review*, October 2004. (http://www.findarticles.com/p/articles/mi_qa4046/is_200410/ai_n9470000)

ESRI ArcGIS™ software. (http://www.esri.com)

Expert Choice™ software. (http://www.expertchoice.com)

Natural Resources Conservation Service – Land Evaluation and Site Assessment (LESA) Program. (http://www.nrcs.usda.gov/programs/lesa/)

Saaty, Thomas L., *Decision Making for Leaders: the Analytical Hierarchy Process for Decisions in a Complex World,* 1982.

Optimization

Ando, A, J. Camm, S. Polasky, and A. Solow. 1998. Species distributions, land values, and efficient conservation. *Science* 279: 2126-2128.

Babcock, B.A., P.G. Lakshminarayan, J. Wu, and D. Zilberman. 1996. The Economics of a Public Fund for Environmental Amenities: a study of CRP contracts. *American Journal of Agricultural Economics* 78: 961-971.

Babcock, B.A., P.G. Lakshminarayan, J. Wu, and D. Zilberman. 1997. Targeting Tools for the Purchase of Environmental Amenities. *Land Economics* 73(3): 325-39.

Frontline Systems, Inc. Premium Solver Platform ™ Software. (http://www.solver.com)

Messer, K.D. 2006. "The conservation benefits of cost-effective land acquisition: A case study in Maryland" *Journal of Environmental Management*.

Messer, K.D. and Wolf, J. 2004. "Optimizing the Conservation Portfolio." *Exchange.* Land Trust Alliance**.** Washington D.C., pp. 11-14. (http://www.ltanet.org)

Microsoft Excel™ software (http://www.microsoft.com)

Polasky, S., J.D. Camm, and B. Garber-Yonts. 2001. Selecting Biological Reserves Cost-effectively: an application to terrestrial vertebrate conservation in Oregon. *Land Economics* 77(1): 68-78.

Underhill, L.G. 1994. Optimal and Suboptimal Reserve Selection Algorithms. *Biological Conservation* 70:85-87.

Wu, JunJie, David Zilberman, and Bruce A. Babcock. 2001. "Environmental and Distributional Effects of Conservation Targeting Strategies." *Journal of Environmental Economics and Management* 41:333-350.

Non-Traditional Conservation Partners

Amundsen III, Ole. "Overcoming Obstacles in Conserving College and University Lands", *Exchange*, Fall 2005, Vol. 24. No. 3. (http://www.ltanet.org/)

Anderson, Jennifer. "Conservation Partnerships with the Military", *Exchange*, Fall 2005, Vol. 24. No. 3. (http://www.ltanet.org/)

The Conservation Fund's Carbon Sequestration Program (http://www.conservationfund.org/?article=3127)

Delaware Ecological Network

Blackbird-Millington Corridor Conservation Area Plan. 2004. (http://www.dnrec.state.de.us/nhp/information/blackbird.asp)

Bushman, E. S., and G. D. Therres. 1988. Habitat management guidelines for forest interior breeding birds of coastal Maryland. Wildlife Tech. Pub. 88-1, Maryland Dept. of Nat. Res., Annapolis, MD. 50pp.

Herkert, J.R., R.E. Szafoni, V.M. Kleen, and J.E. Schwegman. 1993. Habitat establishment, enhancement and management for forest and grassland birds in Illinois. Natural Heritage Technical Publication #1, Illinois Dept. of Conservation, Springfield, IL. 22 pp.

Hodges, M. E. Jr., and Krementz, D. G. 1996. Neotropical migratory breeding bird communities in riparian forests of different widths along the Altamaha River, Georgia. Wilson Bull. 108(3):496-506.

Jones, C., J. McCann, and S. McConville. 2000. A guide to the conservation of forest interior dwelling birds in the Chesapeake Bay Critical Area. Chesapeake Bay Critical Area Commission, Annapolis, MD. 63 pp.

Mason, J., C. Moorman, G. Hess, and K. Sinclair. 2005. Designing suburban greenways to provide habitat for breeding birds (draft version).

Robbins, C. S., D.K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildlife Monographs 103:1-34.

Rowsell, M. 2004. State of Eastern Ontario Forests. (http://sof.eomf.on.ca)

Semlitsch, R.D., and J. Jensen. 2001. Core habitat, not buffer zone. The National Wetlands Newsletter Vol. 23, pp. 5-6, Environmental Law Institute, Washington, D.C.

Vidra, R. 2004. Implications of exotic species invasion for restoration of urban riparian forests. PhD Thesis, North Carolina State University, Raleigh, NC.

acknowledgements

Kent County Rapid Assessment of Green Infrastructure Project Team Members

- William L. Allen, III, Director of Strategic Conservation Programs, The Conservation Fund
- Ole M. Amundsen III, Principal, Land Conservation and Planning
- Dr. Mark A. Benedict, Senior Associate, Strategic Conservation, The Conservation Fund
- Kendra Briechle, Manager, Center for Conservation and Development, The Conservation Fund
- Dr. Kent D. Messer, Research Associate, Department of Applied Economics and Management, Cornell University
- Erik J. Meyers, Vice President, Sustainable Programs, The Conservation Fund
- Blaine T. Phillips, Jr., Mid-Atlantic Regional Director, The Conservation Fund
- Ted C. Weber, Strategic Conservation Analyst, The Conservation Fund
- Jo Gravely, freelance photographer/designer, Ithaca, NY

Kent County Green Infrastructure Leadership Forum Members

- Metta Barbour, Delaware Greenways
- Phil Carpenter, Delaware Division of Fish and Wildlife
- David Edgell, Delaware Office of State Planning Coordination
- Brad Killian, Delaware Greenways
- Andy Manus, The Nature Conservancy
- Michael H. McGrath, AICP, Delaware Agricultural Lands Preservation Foundation
- Dawn Melson, City of Dover
- Michael Petit de Mange, Kent County Department of Planning Services
- Ralph A. Reeb, Delaware Department of Transportation
- Oscar Reed Jr., Bombay Hook National Wildlife Refuge
- Michele Robinette, Kent County Tourism Convention and Visitors Bureau
- E. Austin Short, III, Delaware Forest Service
- Carl J. Solberg, Kent County Levy Court, Parks Division

Delaware Ecological Network – Personal Correspondence

- Peter Blank, University of Maryland
- David Burke, Burke Environmental Associates LLC
- Lonnie S. Dye, Delaware Department of Natural Resources and Environmental Control
- Glenn Gladders, Delaware Department of Natural Resources and Environmental Control
- Amy Deller Jacobs, Delaware Department of Natural Resources and Environmental Control
- Karen Jennings, Straughan Environmental Services
- Elizabeth LaPoint, FIA National Spatial Data Services , U.S. Forest Service, Northeastern Research Station
- Rob Line, Delaware Department of Natural Resources and Environmental Control
- Richard McCorkle, U.S. Fish and Wildlife Service
- Lawrence T. Pomatto, Delaware Department of Natural Resources and Environmental Control

The Conservation Fund would like to thank Michael McGrath, Robin West, and Danielle Klosowski from DALPF for their cooperation in assembling the data used in the agricultural land analysis and commends DALPF for its willingness to undergo an historic analysis. The staff's support of this project demonstrates its openness to examining new ideas and techniques in its continuing efforts to protect Delaware's agricultural lands.

National Office
1655 N. Fort Myer Drive
Suite 1300
Arlington, VA 22209-3199
Phone: 703.525.6300
Fax: 703.525.4610

Partners in Land and Water Conservation