Blackbird Creek Reserve

Ecological Restoration Master Plan

March 2007

BLACKBIRD CREEK RESERVE
ECOLOGICAL RESTORATION MASTER PLAN

Prepared for:
Delaware Department of Natural Resources and
Environmental Control
Delaware National Estuarine Research Reserve
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1.0 INTRODUCTION

1.1 Project Background

The Delaware National Estuarine Research Reserve (DNERR) is one of 27 National Estuarine Research Reserve System (NERRS) sites in the United States. The Reserve System was established by the Coastal Zone Management Act of 1972, as amended, as each reserve involves a partnership between the National Oceanic and Atmospheric Administration (NOAA) and the state the reserve occurs is located. The DNERR is a partnership between NOAA and the Delaware Department of Natural Resources and Environmental Control (DNREC), Division of Soil & Water Conservation—Coastal Programs Section. The DNERR consists of two Reserve components, the Upper Blackbird Creek Reserve Component (hereafter referred to as the Blackbird Creek Reserve) and the Lower St. Jones River Reserve Component, that are located about 30 miles apart (Figure 1.1). These two reserve components include both brackish and freshwater estuaries and are representative of the diverse array of estuarine ecosystems found throughout the Mid-Atlantic States (DNERR 2004). The important ecological values and relatively intact ecosystem components of the Blackbird Creek channel, corridor and watershed are what led to its selection for inclusion as part of the DNERR. This document is an ecological restoration master plan for the DNERR-owned parcels of the Blackbird Creek Reserve encompassing approximately 360 acres on four tracts (Figure 1.2) in southern New Castle County, Delaware. This plan is intended to identify and guide ecological restoration initiatives for the DNERR-owned parcels of the Blackbird Creek Reserve.

DNERR owned-properties of the Blackbird Creek Reserve include those purchased in 2004-05, encompassing the Lowe Tract (formerly Odessa Campground) and the Manwaring Tract. Additional land acquired in 2006 is known as the Cornelius Tract. Previously acquired parcels that are also part of the DNERR-owned lands are in the Union Church-Taylors Bridge Tract.

The four tract areas and their prominent features are as follows:

- Lowe Tract (52 acres)—Former campground area, successional upland woods, fallow fields, and tidal marsh fringe
- Manwaring Tract (85 acres)—Fallow fields, farm ponds, narrow riparian woods and tidal marsh
- Cornelius Tract (70 acres)—Upland forest stands, stream valleys, active agricultural fields and a house
- Union Church-Taylors Bridge Tract (150 acres)—Narrow riparian woods, small non-tidal wetland depressions and extensive tidal marsh areas

All DNERR-owned wetlands and forested uplands on the acquired parcels are shall be managed to preserve environmental quality, minimize detrimental impacts and control invasive species (DNERR 2004). This restoration master plan relates to the components of the NERRS mission to provide long-term research, education and interpretation, and the part of DNERR's mission which includes preserving and managing natural resources within the Reserve.

1.2 A Sense of Place--Historical Human Ecology

Since the King of England's original land grant in the late 1600's and William Penn's transfer of much of the Blackbird's lands to the Huguenots, there have been surprisingly few land ownership or land use changes for many of the properties in and around the Blackbird Creek and Reserve parcels.

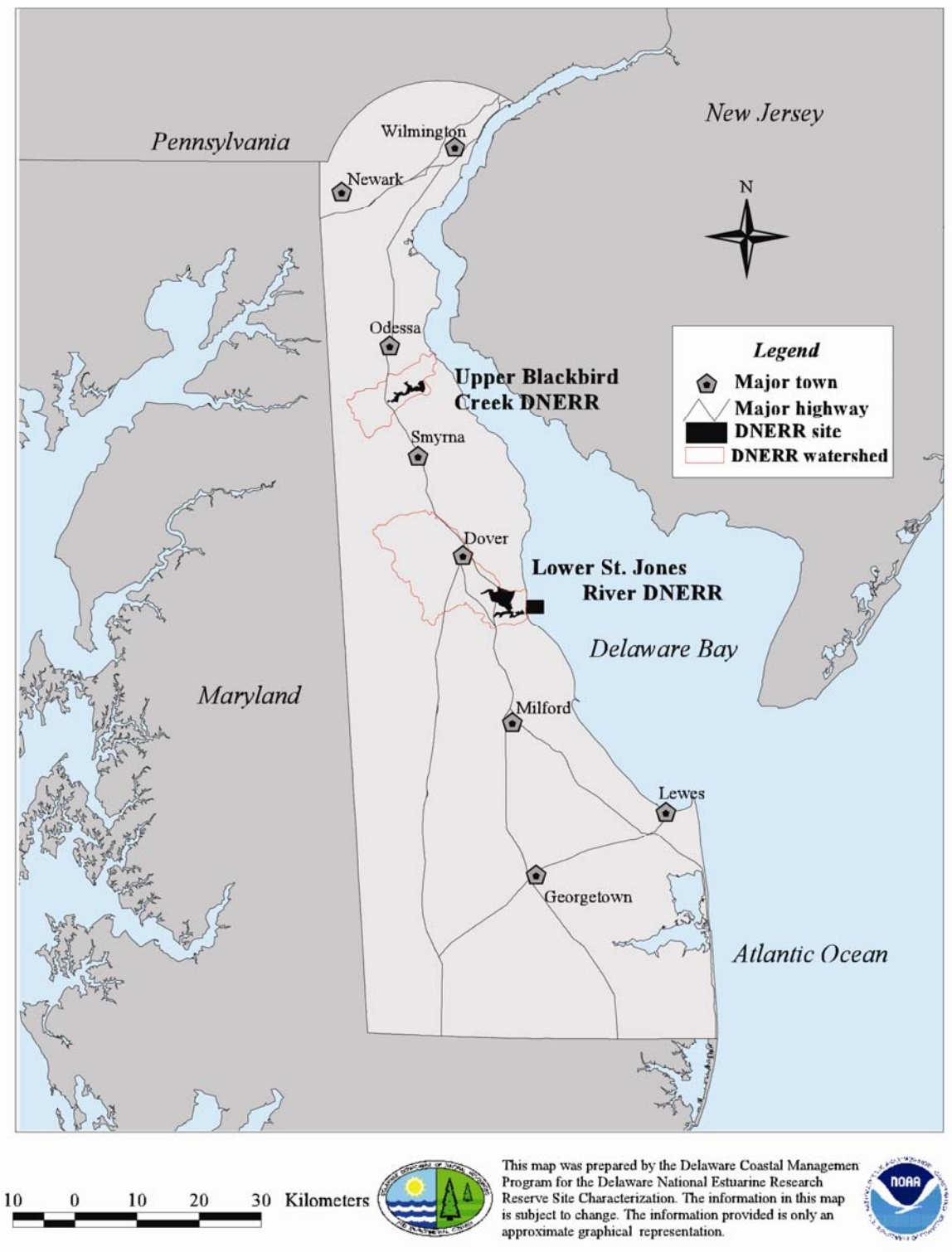
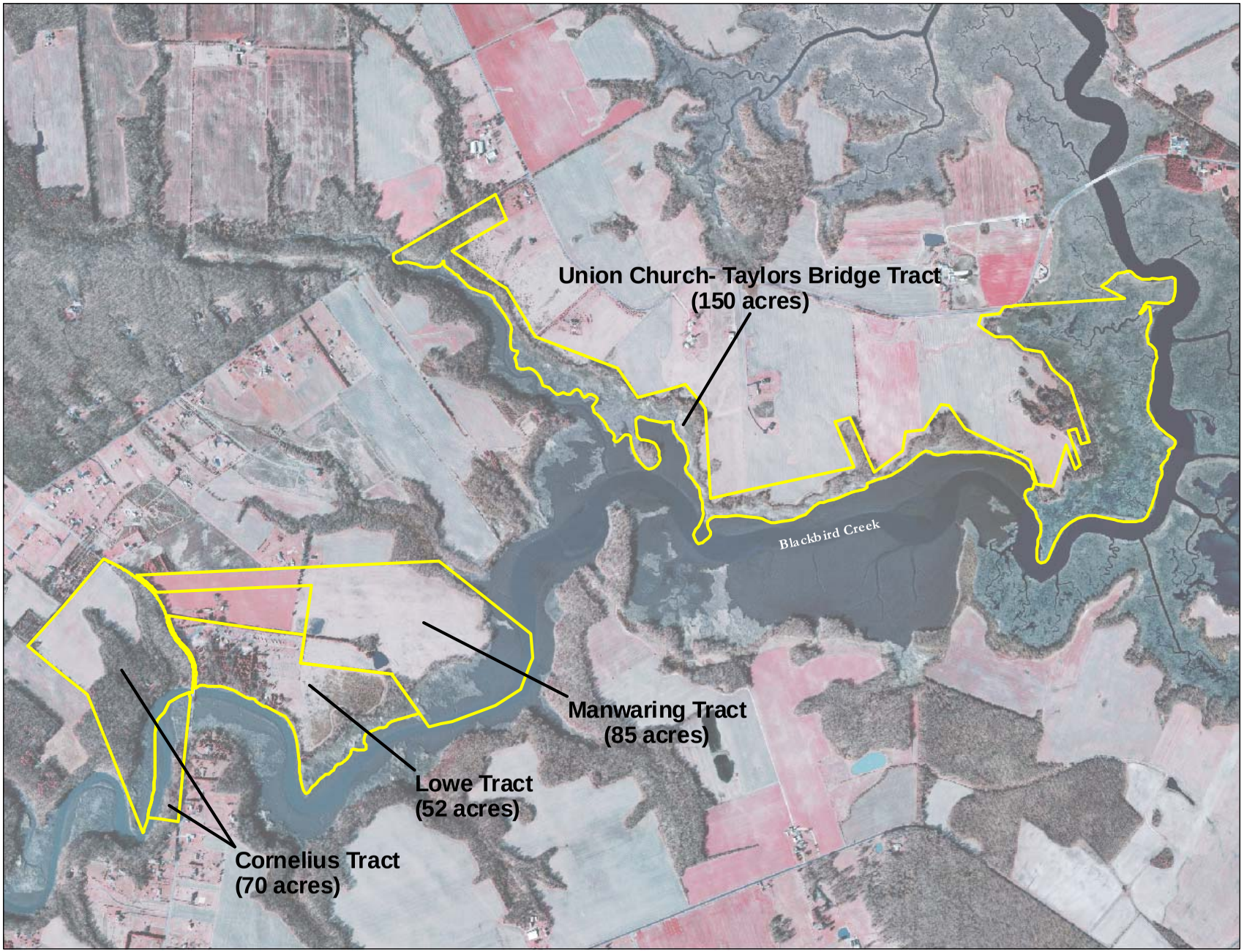


Figure 1.1 Blackbird Creek Reserve Location Map



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DNERR-Owned Parcel Tracts
Figure 1.2

Legend
Blackbird Creek Reserve (DNERR-Owned Parcels)

DATE: 03/07

Biohabitats

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0 312.5 625 1,250 1,875 2,500 Feet

The Blackbird Creek, often called simply "Blackbird", is frequently referred to as an example of one of the only 'pristine' creek systems in north/central Delaware (See watershed map Figure 1.3. This is especially true in comparison to the more heavily altered (filled, channelized or tide-gated) streams, creeks and rivers in northern Delaware.

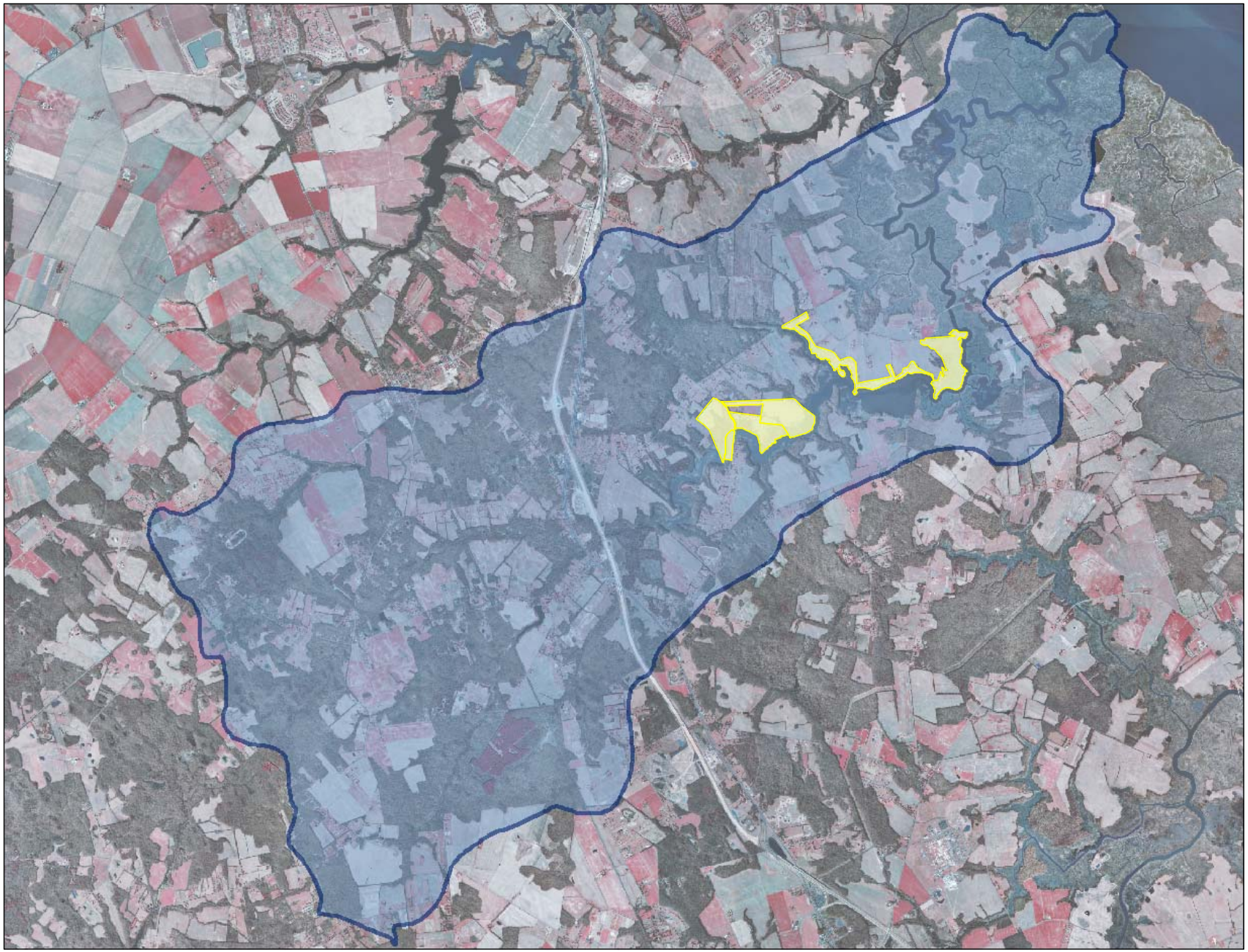
The ecological and cultural setting in which the Blackbird Creek Reserve resides is connected by a history of farming, fishing, hunting, trapping and other resource uses that have long been cornerstones of the local communities and their economy. The Cultural Resource Survey, maintained by the Delaware Bureau of Archaeology and Historic Preservation, lists 73 prehistoric archaeological sites in upland areas fringing Blackbird Creek marsh. While somewhat less so today, the influence of resource-based traditions still have a strong effect on the ecological health, and future of the Blackbird Creek Reserve and the creek system itself. This follows the tradition of generations of farmers, hunters, fishermen and trappers that have highly valued the land and waters of Blackbird Creek's watershed as a provider of resources for their livelihood, residency, recreation and aesthetic enjoyment. The conservation ethic of many of the landowners and stewards of the watershed result from a spirit of place that has developed over time. The Blackbird has a long history of active conservation advocacy by its major property owners, as profiled in the DNREC/NOAA sponsored video, "Blackbird": Delaware's Undiscovered Treasure. Several large conservation organizations, including Delaware Wild Lands, have significant land holdings in the area to protect and conserve important natural areas.

The entire Blackbird Creek Reserve comprises 50 parcels of land held by 46 private landholders in addition to the DNERR properties and other land under the control of the Division of Fish and Wildlife. The recent acquisition of several parcels adding to the Blackbird Component's holdings is only part of the regional conservation effort. The 'buffer' areas for the Reserve core include private landholdings that are protected under the Delaware State Wetlands Act. These buffer areas are permanently protected, but are held in private ownership (DNERR 2004). Many other large parcels in private ownership have been successfully placed in conservation easements. The State's Farmland Preservation Program serves a function of land protection in the watershed. Delaware's Farmland Preservation Program has two major components, Agricultural Preservation Districts and Agricultural Conservation Easements. The occurrence preserved farmland in the Blackbird Creek Reserve area is shown in Figure 1.4.

1.3 About This Plan

The need for an ecological restoration master plan for the Blackbird Creek Reserve, DNERR-owned tracts is clear. The newly acquired parcels in 2004-06 include the former campground and related facilities, as well as a modern suburban home, and several agricultural parcels in various states of cultivation, fallowness and natural condition. The parcels have had varying degrees of human influence and disturbance for many centuries, if not millennia, considering earlier Native American inhabitants. A plan to identify potential restoration initiatives and target conditions is an important step in charting a long term course for the Blackbird Creek Reserve. Without a big picture perspective of the site's ecological restoration needs and priorities, the potential exists for disjointed or uncoordinated efforts without a clear strategy. This ecological restoration master plan will guide the Blackbird Creek Reserve's restoration for immediate short-term efforts and provide a plan of action for the next 15-20 years.

The remainder of this document provides a site conditions assessment and identification of restoration needs (Section 2), restoration context and research framework (Section 3), and restoration recommendations, prioritization, and phasing (Section 4). Additionally, recommendations related to sustainability and stewardship opportunities are identified (Section 5).



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Watershed &
Reserve Area
Figure 1.3

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

Blackbird Watershed Boundaries

DATE: 03/07

Biohabitats

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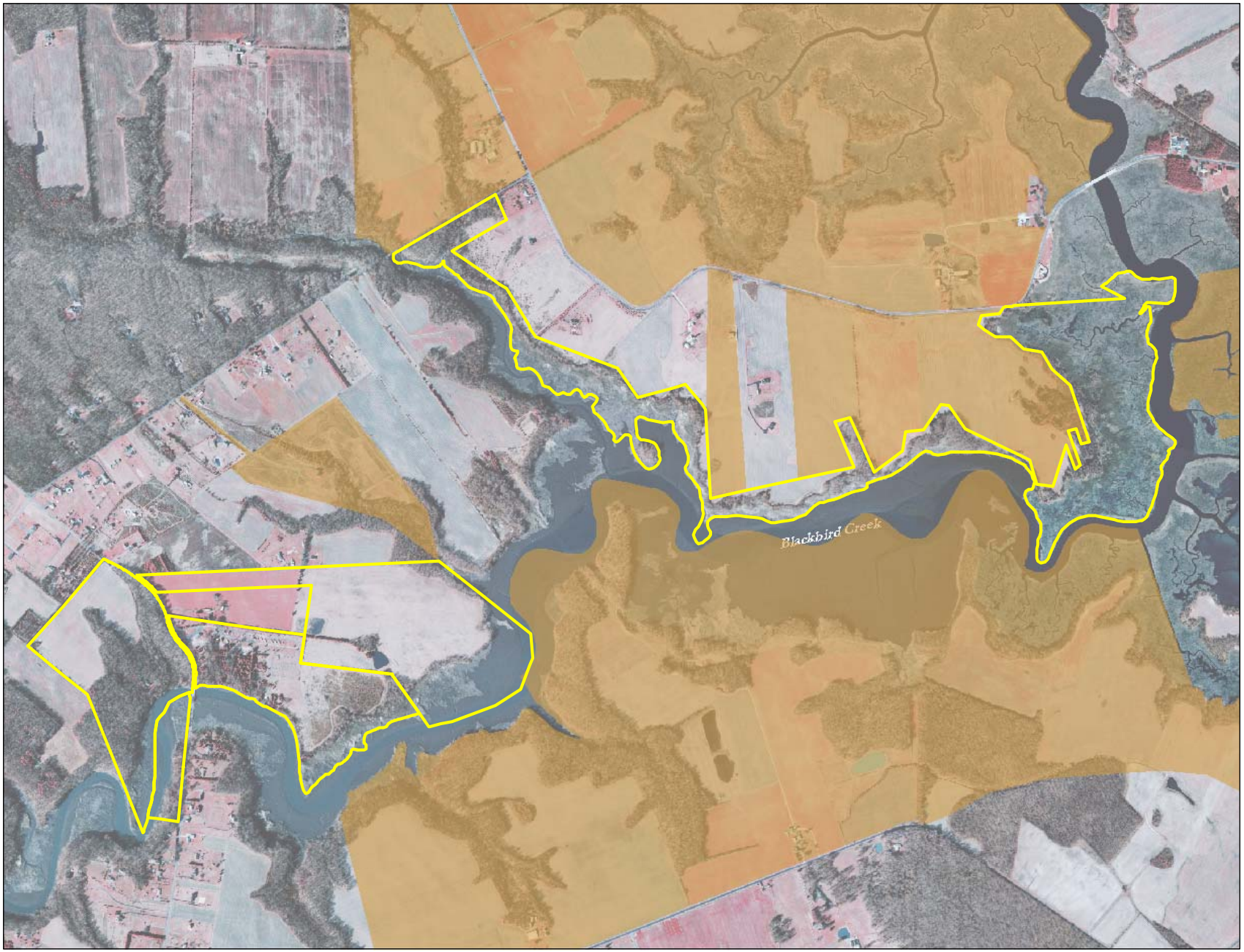
0 1,250 2,500 5,000 7,500 10,000 Feet



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Farm Preservation Program Areas
Figure 1.4

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

Farm Preservation Program Areas

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Biohabitats

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0 315 630 1,260 1,890 2,520 Feet

2.0 SITE CONDITIONS ASSESSMENT

2.1 Existing Information Review and Prior Study Perspectives

Biohabitats reviewed several existing documents and mapping information relating specifically to the Blackbird watershed. This information came from several divisions of Delaware DNREC, Delaware Office of State Planning, NOAA, The Nature Conservancy, NatureServe, and the University of Delaware. These documents include:

- Aerial photographs
- Geographic Information System (GIS)-geospatial maps
- Ecological investigation reports and data
- Natural resource management plans
- Graduate theses
- Peer reviewed journal articles

Previous Reports, Research Investigations and Plans

In the course of developing this restoration management plan, Biohabitats reviewed several management plans, investigation reports and data documents provided by DNREC as well as obtaining other pertinent information independently. These documents include the following (Please see Appendix A for full citations and abstract):

- A Guide to the Natural Communities of the Delaware Estuary
- Detecting and Monitoring *Phragmites* Invasion of Coastal Wetlands: A Comparison of Remote Sensing Techniques
- "Blackbird" Delaware's Undiscovered Treasure (Video)
- Blackbird-Millington Corridor Conservation Area Plan
- Appoquinimink – Blackbird Creek Environmental Profile: GIS map data layers
- Delaware National Estuarine Research Reserve: Estuarine Profiles
- Delaware National Estuarine Research Reserve Management Plan 1993
- Delaware National Estuarine Research Reserve Management Plan 2004-2009
- DNERR Comprehensive Site Description. Phase I – Description / Analysis of Dominant Vegetation / Cover Types.
- Detecting and Monitoring *Phragmites* Invasion of Coastal Wetlands: A Comparison of Remote Sensing Techniques
- Remote sensing of habitat change at Delaware NERRS sites
- Land use / land cover changes and ecological health indicators in the Blackbird Creek watershed: With recommendations for restoration
- Non-native species in our nation's estuaries: a framework for an invasion monitoring program
- Salem Nuclear Power Plant Ecological Baseline Data
- Scrub-Shrub/Emergent Wetland Ecotone Migration Along Delaware Tidal Rivers In Response To Relative Sea-Level Change, Natural Impacts, And Human Modifications
- Shoreline Development Drives Invasion of *Phragmites australis* and the Loss of Plant Diversity on New England Salt Marshes

These invaluable information sources, and others, formed the basis from which this Ecological Restoration

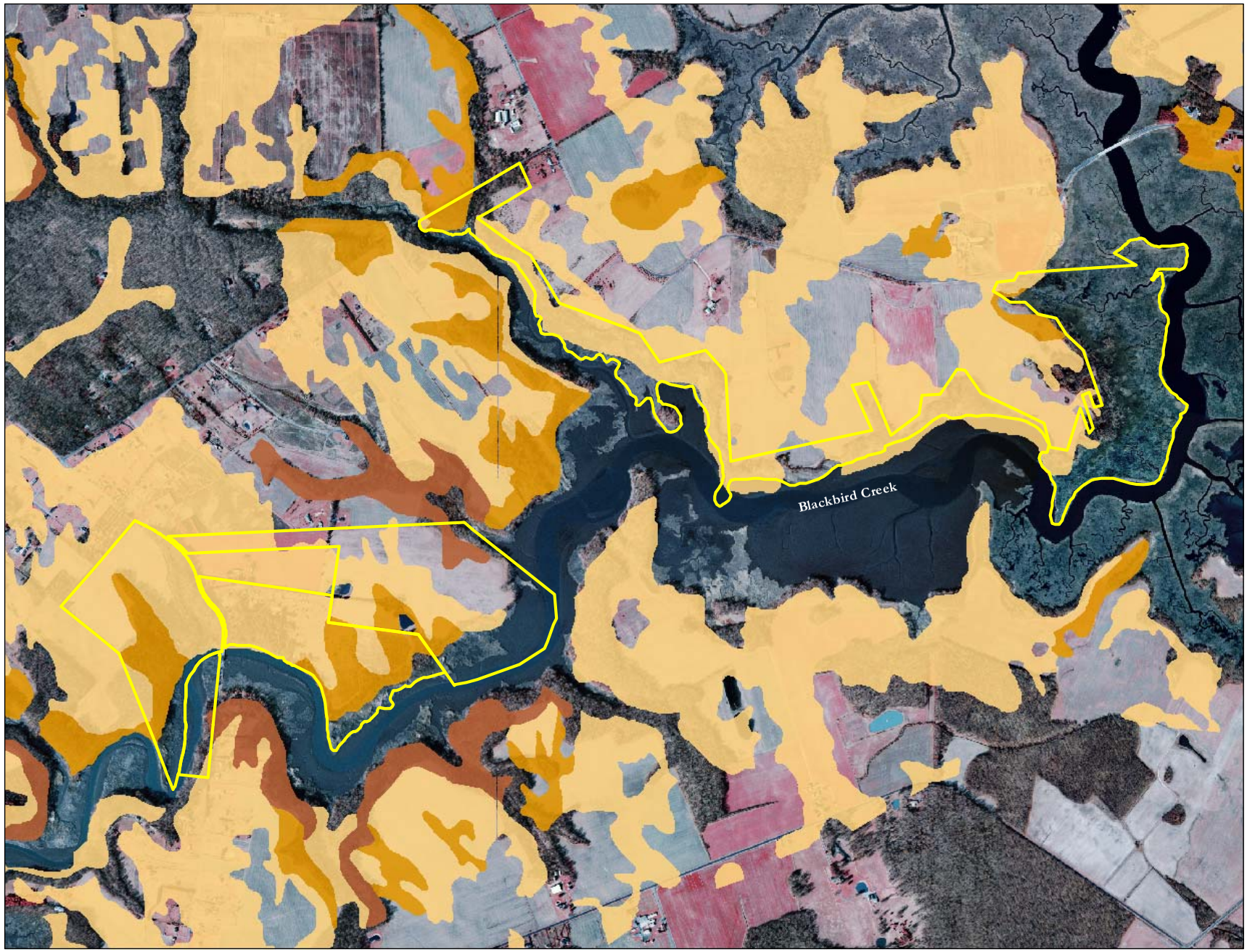
Master Plan document evolved. These sources helped to target potential restoration and research opportunities, characterize existing ecological conditions, and articulate past and more recent resource management activities for the Blackbird Creek area.

2.2 Site Observations

The Blackbird Creek Reserve project area was investigated by Biohabitats in the winter of 2006-07. The main purpose of the site investigation was to characterize the general site conditions, identify potentially ecologically significant resources, and determine ecological needs and restoration opportunities. Previous studies of the Blackbird Creek Reserve area, GIS mapping and personal communications with DNREC managers were all utilized to inform the site investigations.

2.2.1 Streams and Creeks

Numerous tidal creeks and non-tidal streams are found within the study tracts. The non-tidal headwater streams flow through highly erosive soil types (Figure 2.1), and many have incised significantly and/or have undercut banks and head-cuts. These erosion problems appear to stem from overland run-off from fields and in some cases impervious surfaces (i.e. roads). The distribution of stream channels and identified degraded stream reaches are identified in Figure 2.2. Generally, the shoreline banks of the mainstem Blackbird and tidal creeks are very stable with little evidence of active erosion, with the exception of minor erosion at isolated spots. There is a significant and variable width of tidal marsh (fresh to brackish gradient) along the creeks adjoining the study tracts. Tidal creeks and the Blackbird mainstem wetland systems are also facing varying rates of marsh loss, most likely from relative sea level rise, with some suggestion of possible herbivory stressors by foraging geese. The eroding, head-cut and unstable stream reaches identified are a clearly evident restoration need to enhance the streams and protect receiving waters.



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Soil Erodability
Figure 2.1

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

Erodability

- Moderate
- Moderate to Severe
- Severe

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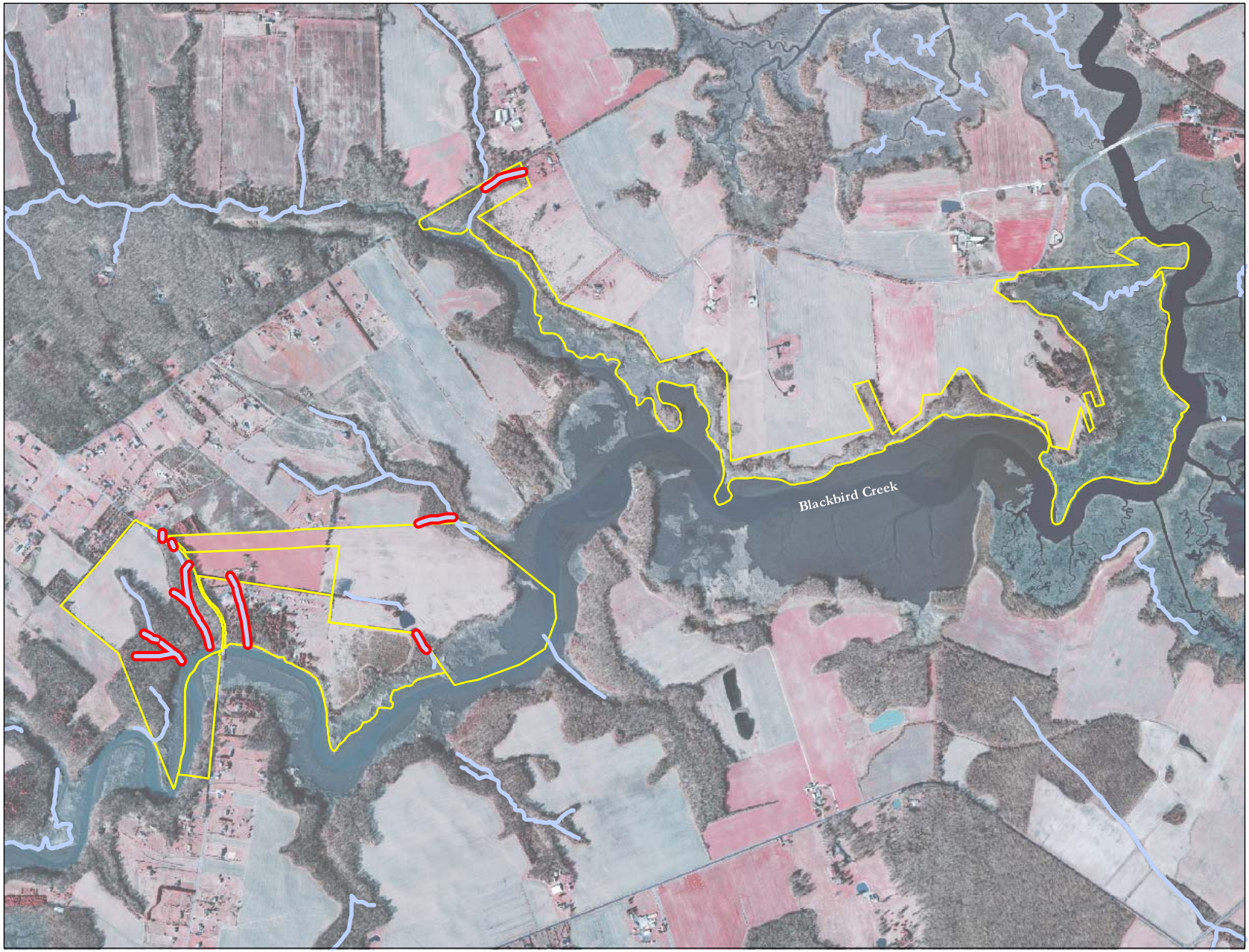

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Degraded Stream Reaches Figure 2.2

Legend

- Blackbird Creek Reserve (DNERR-Owned Parcels)
- Stream Channel
- Degraded Stream Reach

DATE: 03/07

Biohabitats

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0 312.5 625 1250 1875 2500 Feet

2.2.2 Vegetation Communities

The following are the natural community association classifications that correspond most appropriately to the vegetation types identified during site investigations as defined by the National Vegetation Classification System (Figure 2.3) and (Table 2.1). The naming conventions have been referenced from the document *A Guide to the Natural Communities of the Delaware Estuary* (Westervelt *et al.* 2006):

Upland and Riparian Forests

Forest community associations dominated by trees and shrubs are shown in Figure 2.4, and include:

Atlantic Coastal Plain Mesic Hardwood Forest—This community is an upland system found in a variety of moist but non-wetland sites that include lower slopes and bluffs along streams and rivers in fragmented terrain, mesic flats between drier uplands and floodplains, and localized high areas within bottomland terraces or nonriverine wet flats. The vegetation of these forests is typically dominated by combinations of trees that consist of a significant component of mesophytic deciduous hardwood species. Typical species identified through site investigations of the study area are American beech (*Fagus grandifolia*), sweetgum (*Liquidambar styraciflua*), tuliptree (*Liriodendron tulipifera*), and maple species (*Acer sp*.). The understories are usually well-developed with shrub and herb layers that may be sparse or moderately dense. Site evidence of highbush blueberry (*Vaccinium corymbosum*), and field garlic (*Allium vineale*) were noted among others.

Northern Atlantic Coastal Plain Dry Hardwood Forest—This system is comprised of dry hardwood forests mainly dominated by oaks. These forests are found on acidic sandy to gravelly soils, often with an acid loving shrub layer supporting a thick duff. Typical vegetation includes American beech, white oak (*Quercus alba*), northern red oak (*Quercus rubra*) and tulip tree.

Maritime Red Cedar Woodland—This woodland system is found in small groves of varying age in the study area along the upper edges of the tidal river marshes, but most specifically in one older cedar stand associated with the former campground if the Lowe Tract. The eastern red cedar (*Juniperus virginiana*) is the dominant vegetation type with site identification of sweetgum, red maple (*Acer rubrum*), Japanese honeysuckle (*Lonicera japonica*) and field garlic.

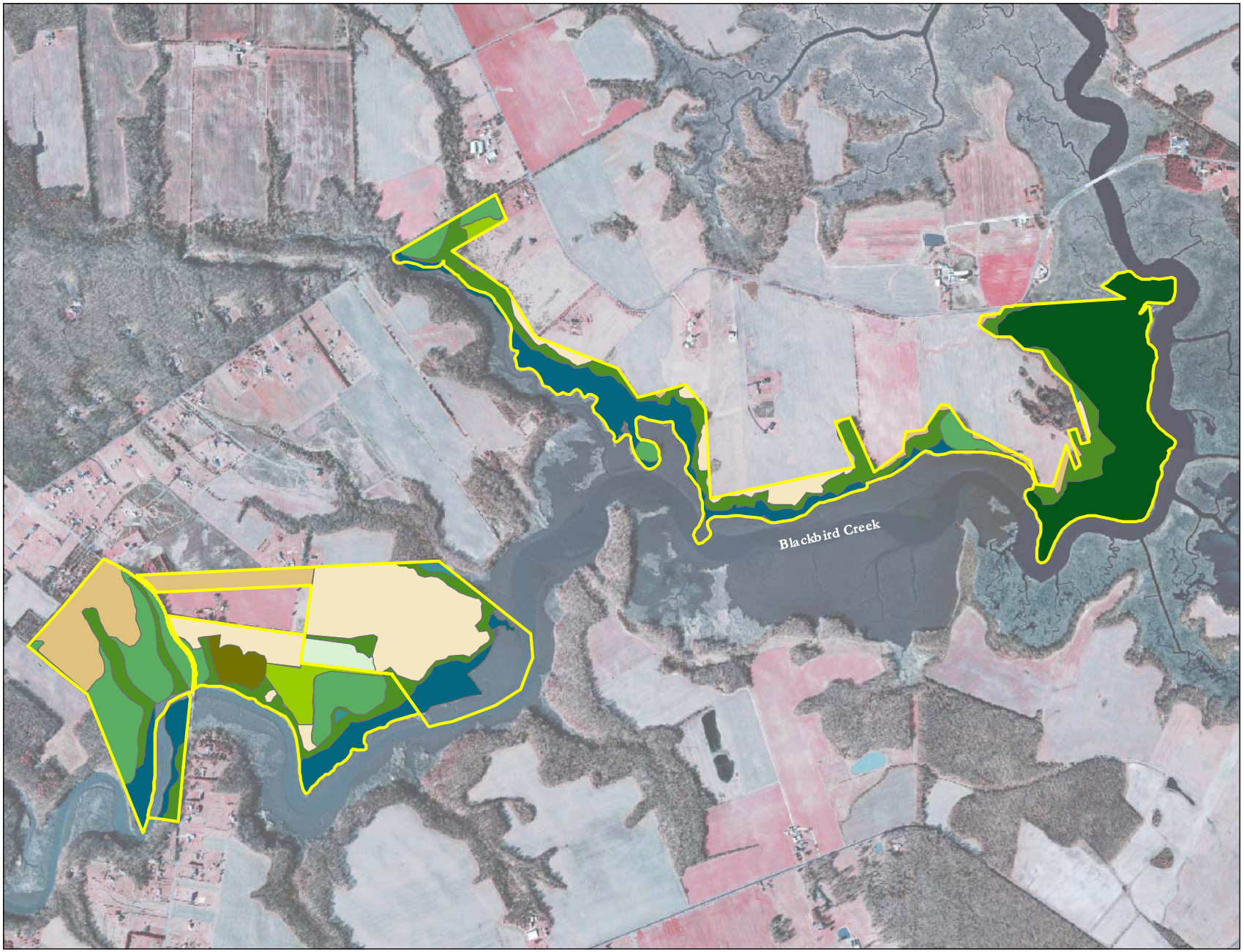
Table 2.1 Vegetation Community Acreages and Percent of Reserve Area

Community Type	**Acreage**	**Percent of Reserve**
Active Agricultural Fields	32.9	9.2
Atlantic Coastal Plain Mesic Hardwood Forest	59.7	16.7
Atlantic Coastal Plain Northern Basin Swamp and Wet Hardwood Forest	1.5	0.4
Maintained Herbaceous	62.3	17.5
Managed Black Walnut Stand	5.0	1.4
Maritime Red Cedar Woodland	5.8	1.6
Northern Atlantic Coastal Plain Dry Hardwood Forest	44.8	12.6
Northern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh	51.7	14.5
Northern Coastal Plain Brackish Tidal Marsh	66.4	18.6
Upland Reforestation Areas	8.6	2.4

While the majority of the Blackbird Creek Reserve study area is in agriculture, several stands of maturing forest exist. These include areas on the Lowe and Cornelius tracts. The largest forest stand (31 Ac) within the DNERR-owned lands is on the Cornelius tract, and it is part of a larger forest block encompassing approximately 67 acres. A significant feature of the forested areas in the Reserve is the generally narrow bands of riparian buffer adjacent to the tidal tributaries and Blackbird Creek mainstem that commonly border agricultural fields. The morphology of these sites vary from low lying, near sea level floodplain forests to narrow bands of trees and shrubs along steep, high banks overlooking the Blackbird Creek and Beaver Branch.

Although there are some high quality patches of mature forest in this stand, high density non-native invasive species occupy the vast majority of the understory and ground cover of the remainder of the stand. Many of the forested upland and riparian forest areas visited during the site investigation were found to be significantly impacted by non-native invasive plants (Figure 2.5). Based on cursory winter-time qualitative observations, the general density and distribution in all vegetation layers in a given area was generally characterized as either low or moderate to high based on relative abundance. The predominant, invasive species identified during the site investigation include multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), wineberry (*Rubus phoencolasius*), field garlic (*Allium vineale*), fescues (*Festuca* spp.) and Canada thistle (*Cirsium arvense*). A recent identification and eradication of a stand of kudzu (*Pueraria montana*) by the Reserve staff at a forest/agriculture field edge on the Cornelius Tract epitomizes the need for timely invasive species identification and control actions.

Restoration needs and opportunities identified for forests include riparian buffer restoration to augment poorly buffered corridors in terms of width and composition (Figure 2.6). Their current condition affects both water quality and habitat connectivity. Additional upland forest restoration is also needed to increase patch size and connectivity.



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Natural Community Associations Figure 2.3

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

Vegetation Communities

- Atlantic Coastal Plain Mesic Hardwood Forest
- Atlantic Coastal Plain Northern Basin Swamp and Wet Hardwood Forest
- Northern Coastal Plain Brackish Tidal Marsh
- Northern Atlantic Coastal Plain Dry Hardwood Forest
- Northern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh
- Managed Black Walnut Stand
- Maritime Red Cedar Woodland
- Upland Reforestation Areas
- Active Agricultural Fields
- Maintained Herbaceaous (Cool Season Grass Meadow and Mowed Lawn)

DATE: 03/07

Biohabitats

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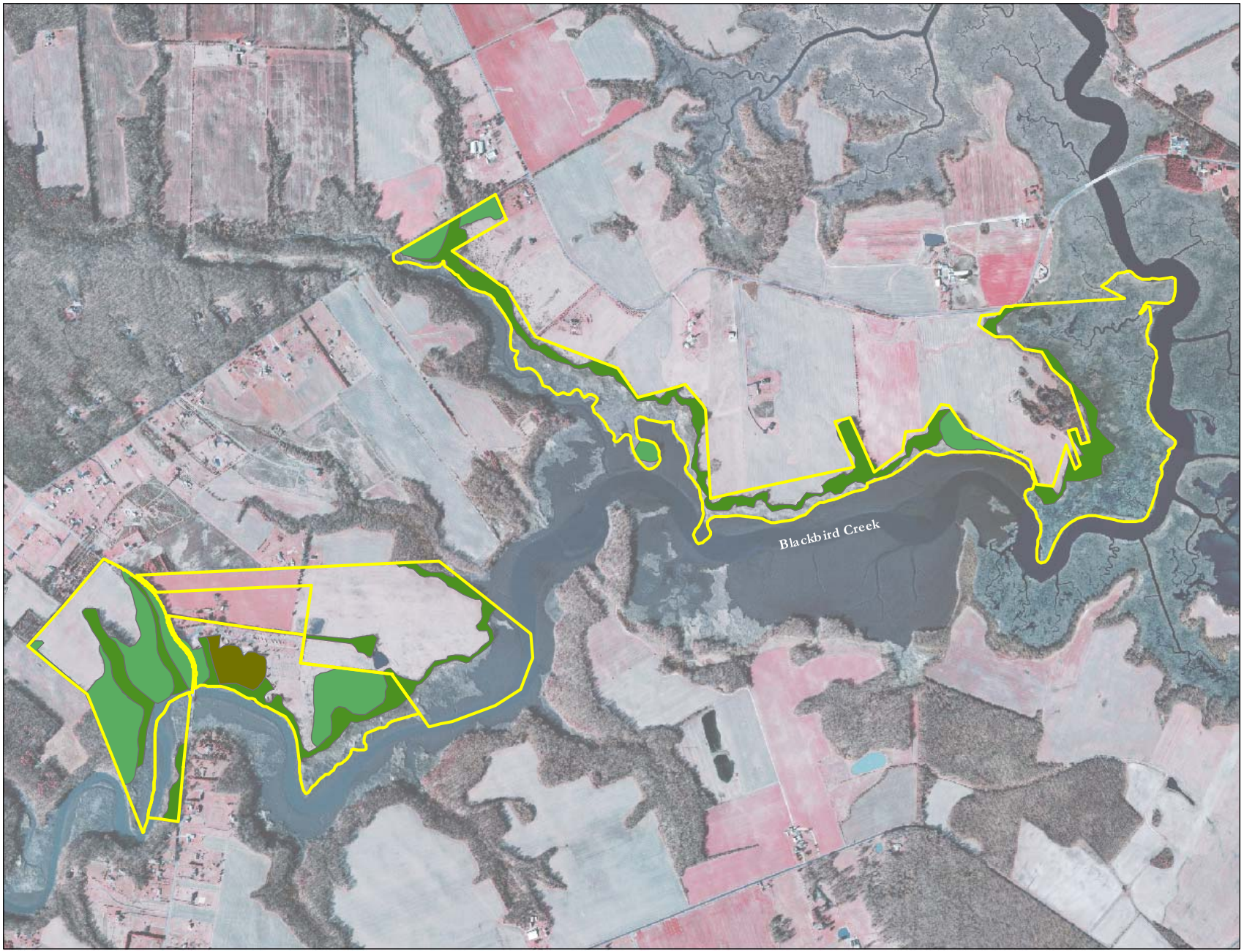

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Upland & Riparian Forest Communities Figure 2.4

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

Vegetation Communities

Atlantic Coastal Plain Mesic Hardwood Forest: 59.7 acres, 16.7% of Reserve Parcels

Northern Atlantic Coastal Plain Dry Hardwood Forest: 44.8 acres, 12.6% of Reserve Parcels

Maritime Red Cedar Woodland: 5.8 acres, 1.6% of Reserve Parcels

DATE: 03/07

Biohabitats

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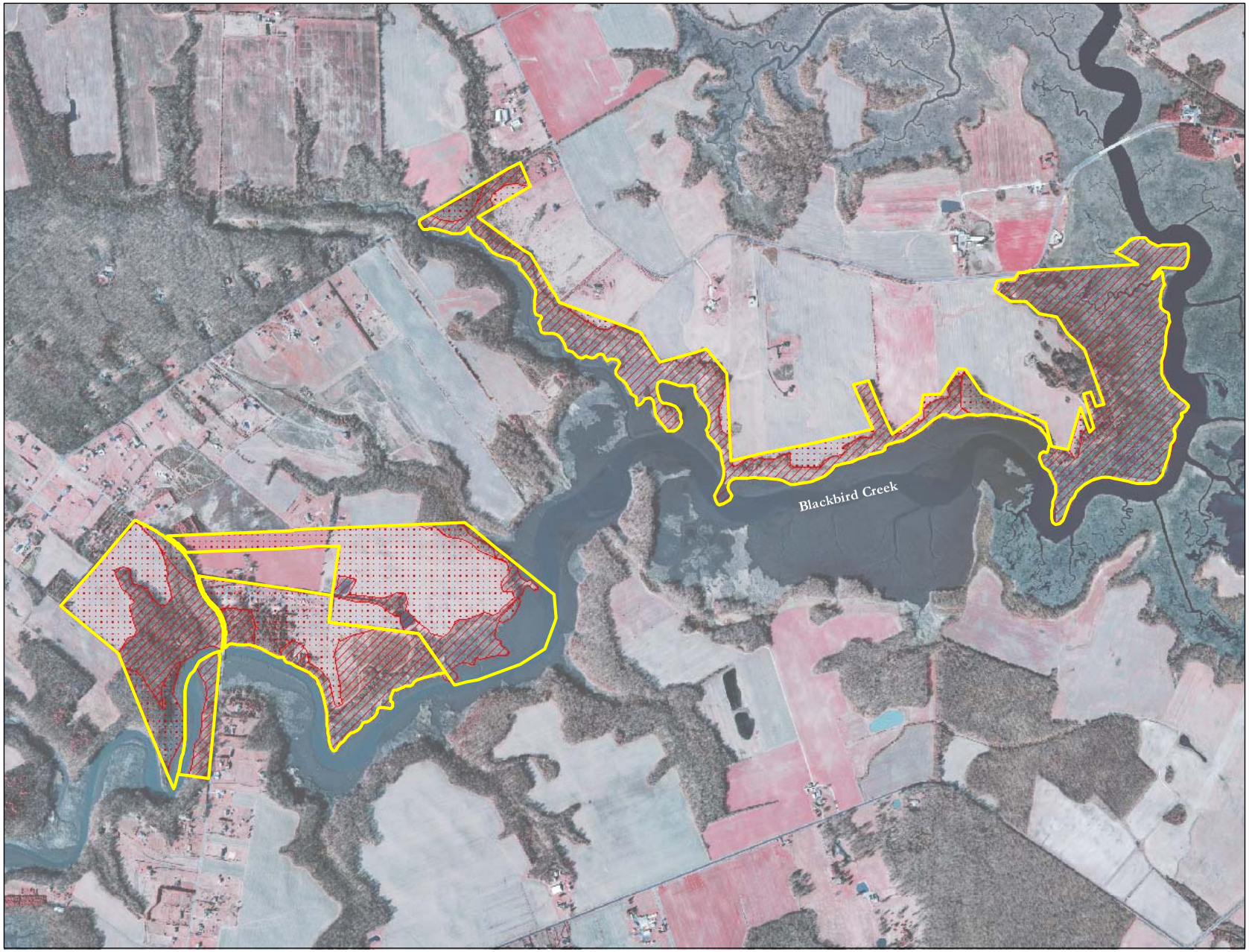

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Non-native Invasive Species General Intensity Observations Figure 2.5

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

General Intensity Observations

Very low to low density

Moderate to high density

DATE: 03/07

Biohabitats

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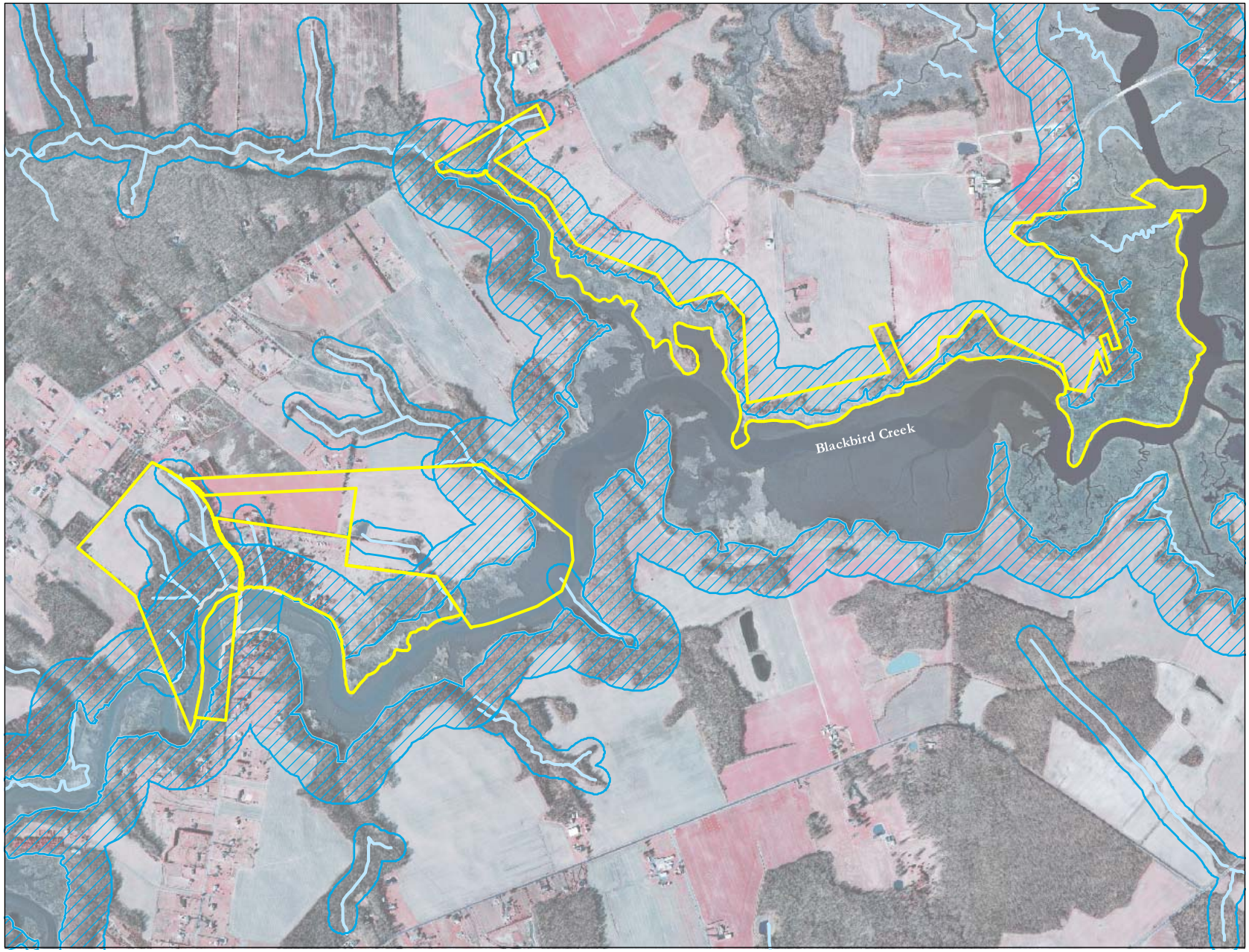
0 312.5 625 1,250 1,875 2,500 Feet



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Riparian Buffer Distribution Figure 2.6

Legend

- Blackbird Creek Reserve (DNERR-Owned Parcels)
- 100m Buffer Zone-- 50m each side of streams
- 300m Riparian Corridor Zone-- 150m each side of main stem creeks
- Streams

DATE: 03/07

Biohabitats

N

0 312.5 625 1250 1875 2500 Feet

Tidal and Non-tidal Wetlands

Tidal and Non-tidal wetland plant community associations (Figure 2.7) include:

Atlantic Coastal Plain Northern Basin Swamp and Wet Hardwood Forest—This system is defined by deciduous hardwoods of seasonally flooded habitats hydrologically supported by shallow groundwater-influenced depressions and stream headwaters. While supporting some seepage characteristics, overland flow to topographic depressions is also a contributor to this system. The soil substrate is mineral in composition overlain with a non-peaty organic layer. Characteristic tree species found during site investigations included red maple, sweet gum, and green ash (*Fraxinus pennsylvanica*).

Northern Atlantic Coastal Plain Brackish Tidal Marsh—This coastal plain tidal marsh system is composed of brackish marshes occurring along the fringes of large tidal rivers and their tributaries where there is some saltwater mixing with freshwater. The typical vegetation associations are distributed within zones according to flooding frequency. Common species include saltmarsh cordgrass (*Spartina alterniflora*), narrowleaf cattail (*Typha angustifolia*), giant cordgrass (*Spartina cynosuroides*), and chair maker's bulrush (*Schoenoplectus americanus*).

Northern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh—This system dominates the majority of the upper Blackbird Creek throughout most of the year as upland freshwater inputs typically overpower the salt wedge. The dominant plant associations are distributed by proximity to tidal waters and their depth and duration of inundation. The majority of the land side fringing marsh has been dominated by the common reed (*Phragmites australis*) for many decades (Bailey 1997). Other vegetation typical for the system includes wild rice (*Zizania aquatica*), water-hemp (*Amaranthus cannabinus*), and eastern rose mallow (*Hibiscus moscheutos*), among others.

The entire tidal marsh system in the area of the tracts is dominated by the highly invasive non-native common reed (*Phragmites australis*).The tidal marshlands of Blackbird have been dominated by common reed for decades and several studies have tracked the advancement of this ubiquitous non-native invasive species. There are also references to the suspected occurrence of one to several stands of the native Phragmites (*Phragmites australis americanus*) along the Blackbird Creek Reserve. Wetland restoration needs and opportunities identified include restoration of fresh and brackish tidal marsh primarily to address non-native plant invasion, along with the opportunity for additional restoration of shall open water to tidal wetlands to counter marsh loss.

Managed Vegetation Types

The Blackbird Reserve study area is dominated by former and active agricultural lands that are in different stages of use and the initial stages of management for other ecotypes. Determining what paths will be followed for their future use and management will significantly dictate the character of the Reserve for years to come. Current managed vegetation types (Figure 2.8) at the Blackbird Creek Reserve include:

- Maintained Herbaceous (Cool Season Grass Meadow and Mowed Lawn)
- Active Agricultural Fields
- Upland Reforestation Areas
- Managed Black Walnut Stand

A portion of the Cornelius tract is still in active agriculture, most of the other former agricultural lands within the DNERR-owned tracts are in varying stages of plant community succession. Different techniques for moving these former agricultural lands into another ecotype (reforestation and regeneration) are currently being employed actively and passively. Regular mowing, upland reforestation plantings with tree tubes, simple unmanaged "no mow" areas, and managing low lying moist fields (that may support an emergent /shrub-scrub wetland trajectory) are all techniques employed to varying degrees throughout the study tracts. As a research component is integral to the reserve, proposals for integrating passive and active restoration methodologies with long term monitoring will provide valuable feedback for this reserve as well as others.

Overall, the managed vegetation types provide opportunities for ecological restoration over the three phases of this master plan. The maintained fallow herbaceous fields on the Manwaring tract are under a Conservation Reserve Program contract and any habitat conversion for restoration cannot occur until after September 30, 2009. The managed vegetation types can be maintained in their current use and land cover until the restoration phases they are identified under are implemented. The managed black walnut stand can be managed for timber production, and potentially converted to natural habitat after the future harvest.

Vegetation Community Sensitivity

In terms of overall sensitivity to disturbance or alteration, the riparian forests, forested non-tidal wetlands, upland forests and tidal wetlands are generally the most sensitive vegetation community types. Riparian forests are sensitive to direct clearing impacts and associated habitat reduction, often resulting in water quality degradation effects. Upland forests (large blocks and corridors) communities are susceptible to fragmentation (reduction of patch size and interior forest area), loss of connection, and related plant and animal habitat availability and species diversity reduction. Forested non-tidal wetlands are susceptible to physical alteration, pollutants and hydrological alterations, which can change structure and function (e.g., hydrologic regime, habitat and support of biodiversity). Tidal wetlands are susceptible to localized and watershed level impacts including hydrologic alterations, stormwater run-off and water quality impairment (e.g., nutrient loadings, and excessive sedimentation), and related non-native plant invasion.

Unique Ecotypes Observed

During the field site investigations, several smaller elements comprised of unique, naturally formed ecotypes were encountered that were not found to be common or widely occurring throughout the Reserve. These unique ecotypes occur on the project parcels as very small patches, typically no more than a few hundred square feet in area. Given the cursory reconnaissance nature of the site observations for this master plan effort, determining the exact extent and distribution of these features throughout the Reserve tracts is not a part of this project. The master plan level observations are not intended to be a comprehensive inventory of ecological resources. However, given the uniqueness of these small ecotype examples to natural system recovery and native biodiversity, the occurrence and general locations of these observed features is important to note (Figure 2.9).

Palustrine Forested Wetland Depressions—Palustrine forested wetlands are characterized by the dominance of woody vegetation 20 feet or taller. These wetland types were found in the study area parcels as small depressions in upland and floodplain areas, with many bordering low areas along the riparian fringes of the tidal creeks. Red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), black willow (Salix nigra), sycamore (*Plantanus occidentalis*) and sphagnum (*Sphagnum sp*.) are several species that occur in these wetland areas.

Blackbird Creek Reserve
Ecological Restoration
Master Plan

Tidal & Non-Tidal Wetlands
Figure 2.7

Legend

Blackbird Creek Reserve
(DNERR-Owned Parcels)

Vegetation Communities

Northern Coastal Plain
Brackish Tidal Marsh:
66.4 acres, 18.6% of Reseve Parcels

Atlantic Coastal Plain Northern Basin
Swamp and Wet Hardwood Forest:
1.5 acres, 0.4% of Reserve Parcels

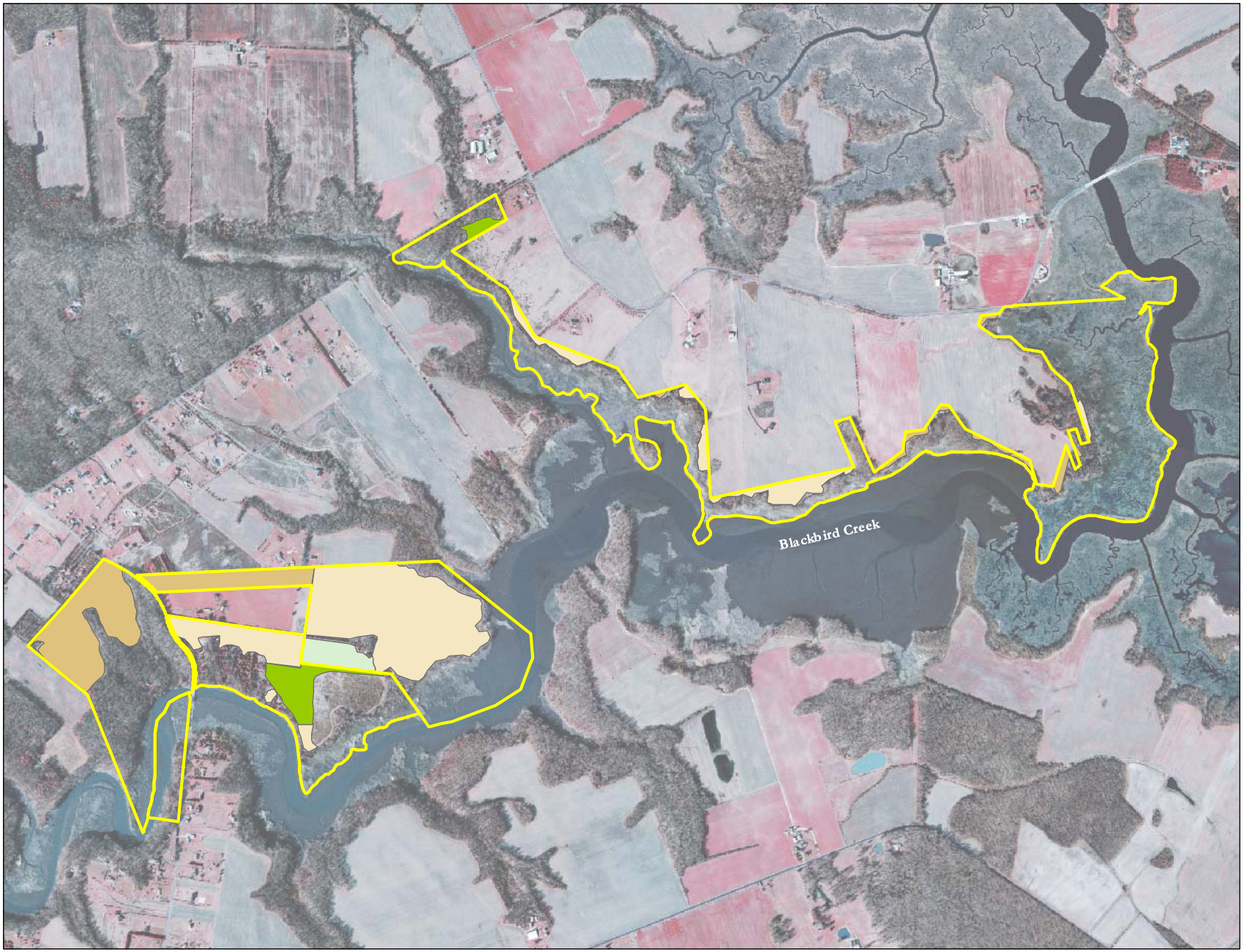
Northern Atlantic Coastal Plain Fresh
and Oligohaline Tidal Marsh:
51.7 acres, 14.5% of Reserve Parcels

DATE: 03/07

Biohabitats

N

0 315 630 1,260 1,890 2,520 Feet



Blackbird Creek Reserve
Ecological Restoration
Master Plan

Managed Vegetation Types Figure 2.8

Legend

Blackbird Creek Reserve
(DNERR-Owned Parcels)

Vegetation Communities

Maintained Herbaceaous (Cool Season Grass Meadow and Mowed Lawn):
62.3 acres, 17.5% of Reseve Parcels

Active Agricultural Fields:
32.9 acres, 9.2% of Reserve Parcels

Managed Black Walnut Stand:
5.0 acres, 1.4% of Reserve Parcels

Upland Reforestation Areas:
8.6 acres, 2.4% of Reserve Parcels

DATE: 03/07

Biohabitats

N

0 312.5 625 1,250 1,875 2,500 Feet

Blackbird Creek Reserve
Ecological Restoration
Master Plan

Unique Ecotypes
Figure 2.9

Legend

Blackbird Creek Reserve
(DNERR-Owned Parcels)

Ecotypes
Existing Forested Wetlands

Forested Wetland Depression

Unique Habitat Elements

Bald Cypress Regeneration

Coastal Plain Pond

Emergent/Scrub Shrub

Hillside Seep Wetland

Native Meadow Regeneration Patch

DATE: 03/07

Biohabitats

N

0 312.5 625 1,250 1,875 2,500 Feet

Emergent/shrub-scrub Wetlands—These palustrine wetland types reflect a mix of herbaceous vegetation and low woody species (shrubs, vines and saplings). They are found as small patches in the study parcels in depressional areas of temporarily flooded meadows as well as along the wetter areas of the riparian zone and transition woodland edges bordering the Blackbird Creek and Beaver Branch. Vegetation found in these areas includes various sedges (*Carex sp*.), soft rush (*Juncus effusus*), goldenrods (*Solidago spp*.), and multiflora rose (*Rosa multiflora*), as well as saplings from deciduous trees such as red maple, green ash (*Fraxinus pennsylvanica*) and sweet gum.

Hillside Wetland Seep—This unique wetland type forms from the emergence of groundwater from a hillside, saturating the slope along the northern edge of the Manwaring tract. These conditions found in a location on one of the study parcels supported forested and herbaceous emergent vegetation types, including red maple and tulip poplar (*Liriodendron tulipifera*), as well as skunk cabbage (*Symplocarpus foetidus*) and sphagnum. The study parcel seep eventually met a headwater tidal marsh tributary of Blackbird Creek.

Bald Cypress Colonization—This unique plant species occurrence on the south-eastern edge of the Manwaring tract is somewhat of a mystery. Three, approximately 20 foot tall bald cypress (*Taxodium distichum*) trees are found within a larger patch of common reed (*Phragmites australis*), and no mature bald cypress were observed in the vicinity. The Blackbird Reserve is on the far northern edge of the range of bald cypress, although many bald cypress have been planted in Delaware and further north. The similar age and grouping of these trees in a cluster along the river shoreline may indicate colonization from propagules brought in from upstream populations, or possible they were intentionally planted.

Native Meadow Grassland Patches—While plenty of meadow habitat (maintained herbaceous fields) is evident on each of the study parcels, there are very few areas that support a native meadow community not overrun with invasive non-native species. Little bluestem (*Schizachyrium scoparium*), broomsedge (*Andropogon virginicus*), goldenrods (*Solidago* spp.), and aster (*Aster sp*.) are among the species found in these patch areas in the study parcels. Their occurrence indicates some native meadow regeneration potential from the soil seed bank.

A program for monitoring these natural elements within their larger systems should focus on detecting physical and biological changes spatially and temporally to the ecotype. The early identification of changes to these systems may require a quick response on the part of Reserve managers to prevent their loss, present an opportunity to encourage the expansion of their coverage, or move the system into a different ecotype. The long term monitoring of the Reserve's natural condition is not only a mandate of the NERR system, it is a useful tool in the detection of ecosystem changes that can be utilized for targeted management decision making and actions.

State and Federally Listed Species

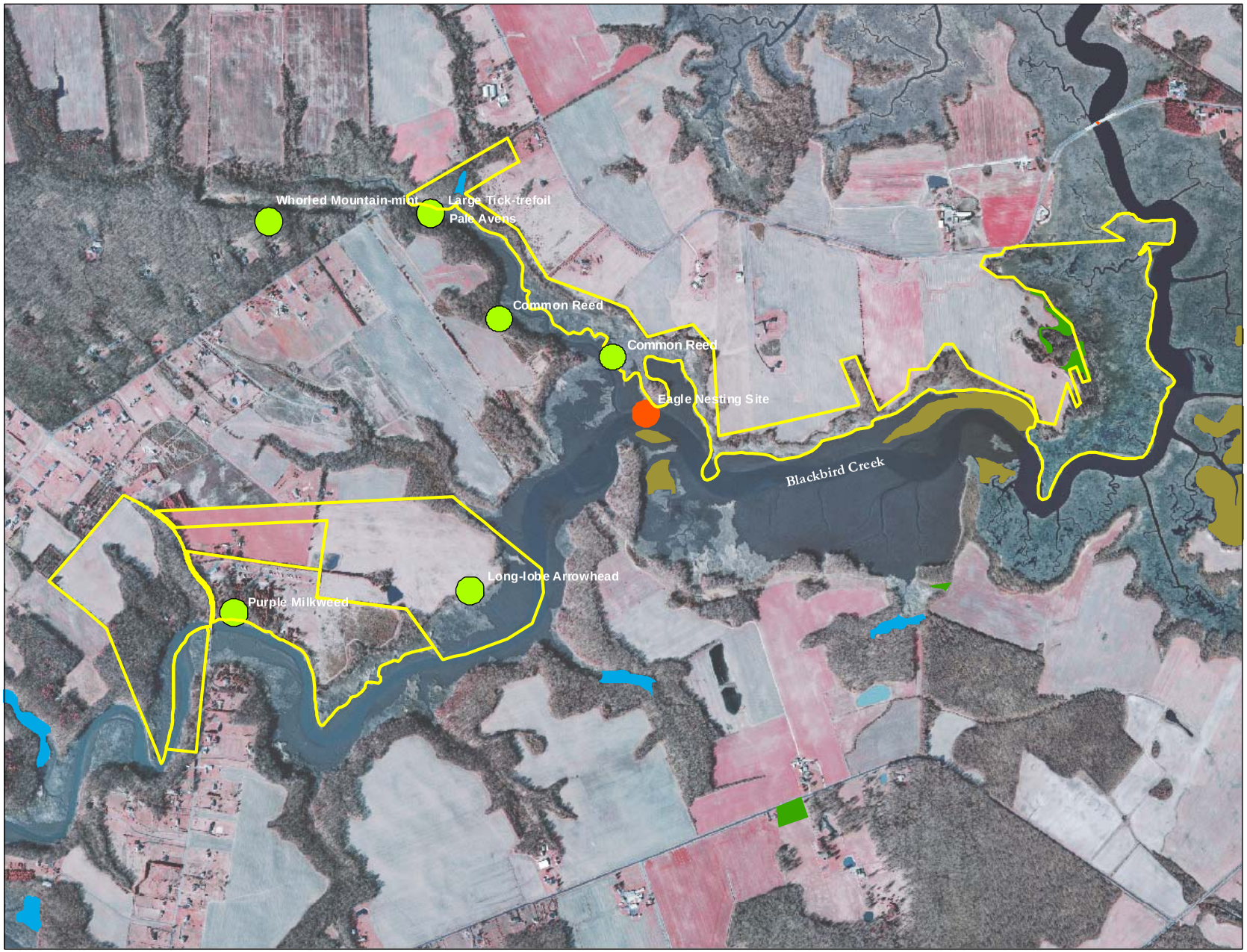
As part of its mission to track the status of rare and uncommon species of flora and fauna within the state, The DNREC-Delaware Natural Heritage and Endangered Species Program (DNHESP) utilizes a ranking system developed by The Nature Conservancy (TNC). A state rank reflecting the degree of rarity within Delaware has been assigned to each species in addition to a global rank which applies to rarity worldwide. There are four listed rare plant species and one animal species identified by the DNHESP as being found on the Blackbird Creek Reserve parcel tracts (Table 2.2). A fifth rare plant species, whorled mountain mint (*Pycnanthemum verticillatum*), is identified to occur near the Reserve parcels. The native common reed (*Phragmites australis*, var *americanus*) is not on the rare plant list, but it is on the State Watchlist of Uncommon Vascular Plants of Delaware, and it has a State Rank of SU (Status Uncertain). None of the plant species are federally listed, while the bald eagle (*Haliaeetus leucocephalus*) is federally listed as threatened. The bald eagle is also listed as Delaware State Endangered. A pair of bald eagles was observed actively nesting on an island at the confluence of Blackbird Creek and Beaver Branch during the site reconnaissance for this plan.

The location of known rare plant and animal species, as provided by the DNHESP, is provided in Figure 2.10. These locations represent recorded occurrences and do not indicate the only potential occurrences of rare plant or animal species within the Reserve parcels. The general ecological characterization observations were part of a limited, winter-time reconnaissance for this master plan project, and are not intended to provide a comprehensive rare species survey. Conducting a detailed multi-season and multi-year inventory and distribution study (and long term tracking) of rare plant and animal occurrences on the tract parcels is highly recommended. Information from a rare species study can then be used to further inform the restoration recommendations in this master plan, and conducting a rare species inventory in the vicinity of any ground disturbance or site clearing activity is imperative prior to project implementation.

Table 2.2 Rare Plants, and Animals of Conservation Concern as Identified by DNHESP

Scientific Name	Common Name	State Rank	Global Rank
Asclepias purpurascens	purple milkweed	S2	G4 G5
Desmodium glutinosum	large tick-trefoil	S2	G5
Geum virginianum	pale avens	S1	G5
Pycnanthemum verticillatum	whorled mountain mint	S2	G5 T5?
Sagittaria spatulata	long-lobe arrowhead	S3	
Haliaeetus leucocephalus	bald eagle	S2B S3N	G4

S1= Extremely Rare within the state
S2= Very Rare within the state
S3= Rare to Uncommon within the state
B=Breeding N=Nonbreeding
G4= Apparently secure globally, but uncommon in parts of its range
G5=Secure on a global basis, but the species may be uncommon on a local basis
T5=Intraspecific taxon ranked differently



Blackbird Creek Reserve
Ecological Restoration
Master Plan

Rare Plants and Key Wildlife Habitats Figure 2.10

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

Rare Species Occurrence

- Rare Plants
- Species of Greatest Conservation Need

Key Wildlife Habitats

- Early Successional Habitat
- Freshwater Tidal Forested and Scrub-Shrub Wetlands
- Unvegetated Intertidal Mudflat

DATE: 03/07

Biohabitats

N

0 260 520 1,040 1,560 2,080 Feet

2.2.3 Human Structures—the Built Environment

The Lowe Tract was purchased from an owner that had utilized the property as a campground for recreational vehicles and trailers. The structures have been razed and removed, although old and broken paved interior roads and parking surfaces, a small man-made pond, and other remnants of the campground still persist.

Additionally, a property acquisition that included a large suburban type modern home is intended for use as flexible space for offices, small meetings and equipment storage. Identified site features that are specifically anthropogenic in nature are shown on Figure 2.11.

2.3 Ecological Resource Impacts & Restoration Needs

Headwater Streams—Degraded headwater streams are the most apparent physically altered ecological feature on the Reserve parcels based on site reconnaissance observations. They have on-going and continual degradation processes including stormwater run-off conveyance, eroding and under-cut banks, incised channels, and riparian tree undermining and loss. The degraded streams are also directly impacting infrastructure including roads and culverts.

Riparian Buffers—Riparian corridor buffers along streams and creeks are a significant landscape context feature that is insufficient in terms of typical widths, structure and distribution. These deficiencies are evident from prior studies (McCorkle 2000), aerial photograph analysis and on-site existing conditions observations. Buffer enhancement through reforestation is a significant part of the Streamside Conservation Priority as one of the primary 'Conservation Priority Areas' in the Blackbird Millington Conservation Corridor Plan (TNC/DNREC 2005).

Non-native Invasive Species—A wide variety of non-native invasive plant species occur throughout the Blackbird corridor in all natural community habitat types. Within the Blackbird Creek Reserve they are a threat to native plant communities and their biodiversity as indicated by Bailey 1997 and TNC/DNREC 2005. Furthermore, invasive species are a primary management concern identified in the DNERR Management Plan (DNERR 2004), and are a part of the active management on the Reserve parcels. Attention to existing and future invasive species threats is necessary.

Freshwater Nontidal Forested Wetlands—Delaware has lost more than 50% of its historic wetlands resources since colonial times. This includes palustrine forested wetlands experiencing the greatest loss of all wetland types in Delaware from 1981-1992, encompassing 1500 acres (Tiner 2001). Wetland impacts include the loss of 'coastal plain ponds' or Delmarva Bays', and ecologically unique and regionally important type of forested wetland habitat. The Blackbird Reserve is within the distribution area of coastal plain pond occurrence, but this wetland type is only represented by potentially altered remnants remaining of the Reserve parcels. Areas that would have typically been headwater wetlands at the top of streams have been converted to agricultural fields and their function to protect stream channels has been lost.

Tidal Wetlands—Tidal wetlands, particularly emergent marsh, is a prominent habitat feature of the tidal creeks and rivers in the coastal plain of Delaware including Blackbird Creek. Tidal marsh loss and conversion to open water and mudflats, other ecotone shifts, and extensive common reed invasion have been extensively documented in the Blackbird Creek watershed including the Reserve area (McCorkle 2000, Klemas and Field 2004, and Valentine 2002).

Upland Forest—Coastal plain upland forests once covered much of the landscape in the coastal Delaware. Currently the forest cover is reduced to percent of the watershed. Corresponding habitat areas and habitat corridor connections have been lost due to forest conversion and fragmentation. The Forest Priority Conservation Areas identified by TNC/DNREC 2005, focuses on protecting and linking mature forests and also requires filling in gaps with new plantings and/or improvements to existing stands.

Upland Native Meadow—Early successional vegetation stages of native grassland communities occur as variable patches throughout the coastal plain. They help provide a diversity of habitat types for different species assemblages as a part of mosaic of community types in the region. This vegetation type supports native grassland plants and animals and can also serve to function as a valuable habitat 'placeholder' until future targeted efforts under adaptive management perhaps determine a shift to some other habitat type is warranted.

Blackbird Creek Reserve
Ecological Restoration
Master Plan

Anthropogenic Features Figure 2.11

Legend

Blackbird Creek Reserve (DNERR-Owned Parcels)

Anthropogenic Features

- Suburban House
- Trash/Debris Dumping
- Cut Logs/Woody Debris
- Man-made Pond
- Access Drive/Road

DATE: 03/07

Biohabitats

N

0 0.05 0.1 0.2 0.3 0.4 Miles

3.0 ECOLOGICAL RESTORATION & RESEARCH FRAMEWORK

3.1 Restoration Context

Setting the context for ecological restoration is important, as is defining over-arching goals, objectives, rationale and approach for restoration initiatives. The general emphasis of restoration efforts is often to restore damaged or degraded habitats, abate environmental impacts, or re-introduce historically present native species. There are many variations of the definition of ecological restoration by various groups that undertake or advocate restoration (See Mitsch and Jorgensen 2004; Perrow and Davy 2002; and SER 2004). To set the context for ecological restoration for this project we first look to NOAA, the lead organization for the National Estuarine Research Reserve System (NERRS), for their definition of ecological restoration:

The process of reestablishing a self-sustaining habitat that closely resembles a natural condition in terms of structure and function. (NOAA 2002)

3.2 Restoration Rationale

The State of Delaware and the Nature Conservancy recognizes the Blackbird Creek corridor as one of the most ecologically valuable areas of the state's "Green Infrastructure" (TNC and DNREC 2005). The ecological significance of the Blackbird Creek system is recognized as one of the most important remaining natural landscapes in Delaware as documented in the *Blackbird-Millington Corridor Conservation Area* Plan (TNC and DNREC 2005). Evidence from prior studies of this ecosystem and current observations indicate that the Blackbird Creek system is being degraded by invasive species, past agricultural practices and accelerated development in the watershed (Bailey 1997; McCorkle 2000; Valentine 2002; Klemas and Field 2004).

In addition to DNERR's land conversation protection efforts, ecological restoration is needed to counter these trends to protect the Blackbird system from further degradation. Simply relying on unassisted self-recovery of the system may take decades or longer to happen, or may never occur. These factors are the basis for the rationale that ecological restoration efforts are needed for the degraded resources on the DNERR-owned parcels of the Blackbird Creek Reserve. Effective tools for achieving ecological restoration, including an adaptive management approach, are needed for the Blackbird Creek Reserve to benefit the DNERR-owned parcels, as well as to educate and inform management decisions and influence future restoration efforts for the whole system.

3.3 Over-arching Mission and Goals

The over-arching mission and goals of ecological restoration for the Blackbird Creek Reserve are influenced at several levels, including guidance from the National Estuarine Research Reserve System (NERRS) and reserve-specific DNERR Management Plan goals. Additionally, objectives related to achieving these goals were provided by the DNERR Staff and DNREC personnel, specifically related to this ecological restoration master plan. The Reserve management staff also takes into account local community and stakeholder objectives for the Reserve area and its contributing watershed.

The overall NERRS mission is – *'To practice and promote coastal and estuarine stewardship through innovative research and education, using a system of protected areas.'*

A significant component of fulfilling the NERRS mission includes the basic *GOAL* of:

Protecting, restoring and monitoring of local estuarine and coastal resources for each of the Reserve system sites.

The NERRS also has an evolving restoration strategy (see inset).

A Restoration Science Strategy

The National Estuarine Research Reserve System is developing a Habitat Restoration Strategy to provide the scientific basis and technical expertise to restore, enhance and maintain estuarine ecosystems. The plan will develop and transfer effective approaches to identify, prioritize, restore and monitor degraded or lost coastal habitat. The strategy uses a partnership approach coupled with education and community involvement. The restoration areas in which the reserve system hopes to play a national role includes:

- Project planning
- Developing effective approaches to test and evaluate innovative technology for restoration
- Monitoring restoration response
- Serving as local reference or control sites
- Translating/transferring restoration information
- Providing scientific and technological advise to support policy and regulatory decisions
- Building awareness for the value of restoration science
- Coordinating regional science

The NERRS restoration science initiative has set general '*Habitat Restoration Priorities for Each Reserve'*. The DNERR restoration priorities, as determined by the NERRS restoration science initiative, are generally defined as:

- Invasive species
- Upland habitat
- And, Other

The 'Other' category references smaller, local habitat types of concern not representative of the national strategy.

As a companion, the NERRS also identifies '*Lost, Disturbed or Damaged Habitat Within Each Reserve*', and for the DNERR they are as follows:

- Salt/Brackish marsh
- Tidal freshwater wetlands
- Upland forest/meadow
- Riverine/riparian wetlands
- Coastal prairie/scrub

The above priorities are for both the St. Jones River and Blackbird Creek Reserves of the DNERR. Specific priorities for each site are not distinguished.

The Reserve and DNREC staff identified objectives for the outcome of this ecological restoration master plan and implementation process that include:

- Define restoration targets for the plan
- Improve land use activities from a water quality perspective
- Provide a holistic restoration plan for now, and set the stage for long-term monitoring
- Identify associated innovative stormwater techniques
- Produce results on the ground in the near-term
- Lead to demonstration plots for wildlife habitat types (e.g., for mammals)
- Act as a model for others in the watershed

3.4 Restoration Approach

The restoration of the Blackbird Creek Reserve study parcels will involve multiple techniques and restoration approaches. These techniques and approaches are dependant upon the condition of the ecological resources that are targeted for restoration and resources available to achieve the restoration goals.

The scale and focus of restoration effort is an important issue to address for any ecological restoration project or program. Ecological restoration can occur at a variety of levels including a system, community, population or species focus. At broad scales, it becomes even more difficult to decide what should be restored, where and how (Hobbs 2002). Other major considerations revolve around a landscape level ecological context and/or restoring natural functions and processes. Whatever is carried out in the way of restoration should involve working with, and not in opposition to, the natural processes that will form the system in the achievement of a functioning ecosystem (Bradshaw 2002).

The amount and type of intervention is dependent on the degree of degradation or ecological impacts. This can range from reconstruction, to less extensive enhancement, or simply improved management of the resource. Parker & Pickett (1997) indicate that restoration should be considered a process, with the degree of active intervention being determined by contextual circumstances.

Guiding Principles for Restoration

The following *Guiding Principles* are used to guide the conceptual ecological restoration initiatives identified in this plan, and are recommended for associated restoration design and implementation/construction processes.

- Protect and maintain existing habitat patches, and restore habitat to provide larger patches and increase the connectivity of habitat corridors
- Maintain existing high quality habitat conditions and improve degraded habitat conditions by removing threats or threatening processes
- Improve the condition of relic habitats in fragmented landscapes to ensure their persistence
- Emphasize supporting and regenerating natural processes for system recovery
- Conserve non-renewable energy in restoration approaches
- Support ecosystem conservation practices in all related activities
- Use applied monitoring and research to test ecological theories
- Consider human needs and compatibility with the needs of biotic systems

Given the degree to which specific ecological resources have been identified to be degraded or damaged, and other resources are threatened, the *Restoration Approach* for the Blackbird Component parcels is recommended to include:

- Active restoration of specific degraded or impacted existing ecological resources including; non-tidal wetlands, streams and riparian buffers
- Creation of additional habitats that are fragmented, reduced or eliminated from the landscape (including; wetlands, upland reforestation and native meadows)
- Use varying degrees of non-native invasive species management to protect existing natural communities, and as a part of restoring degraded habitat areas
- Identify compatible ideas for sustainable facilities, best management practices (e.g. stormwater), and stewardship opportunities to support restoration
- Adaptive management in the form of restoration implementation, monitoring and informed decision making based on the analysis of the monitoring results.

3.5 Restoration Targets & Trajectory

Inherently, achieving ecosystem restoration of the entire 'Blackbird' system cannot be accomplished in the context of only the Reserve parcels. However, leading by example, the restoration efforts on the Blackbird Creek Reserve can certainly be a significant part of ecosystem restoration. The benefit of the long-term mission and work of the DNERR is that the restoration efforts on the Blackbird Creek Reserve can be accomplished in the broader context of monitoring the changes in the system components. More importantly, the Reserve system research focus affords the opportunity for ecological modeling and entire ecosystem analysis. The key to achieving the Blackbird Creek ecosystem restoration is collaboration with other organizations to monitor and analyze broad-scale efforts. An important aspect of the proposed restoration approach is utilizing adaptive management in the form of restoration monitoring and informed decision making based on the analysis of the monitoring results and natural system responses.

Questions related to defining the specific targets for restoration may be thought of in terms of ecosystems, communities, plant assemblages or individual species. Primarily, what is the trajectory, or pathway to the desired restoration endpoint? To establish targets for ecological restoration it is important to consider the restoration priorities identified by NERRS, and the associated list of lost, degraded or disturbed habitats previously identified in this plan. These Reserve-specific priorities, along with the ecological resources identified to be degraded or lost in this part of the system, form the basis for specific restoration targets recommended. The prioritization, phasing, recommended methods and targets for each identified type of restoration are identified in Section 4 of this master plan.

The information assessed for the Blackbird Creek and watershed indicates that this highly valued system is showing signs of multiple stressors and degrading influences, and its ecological trajectory is showing a downward trend. This master plan recommends that active intervention must be taken to repair or regenerate specific degraded resources on the Blackbird Creek Reserve. Implementation of the restoration initiatives identified in this plan, along with adaptive management by monitoring, analyzing natural system responses, and revising restoration approaches in the future, is intended to assist the system along a recovery trajectory.

3.6 Restoration Research & Monitoring Framework

A critical component of long-term restoration success is the application of applied research and monitoring. These efforts will not only document the restoration site conditions upon implementation, but also serve to track natural system responses and trends. Restoration is not only a problem-solving matter; it is a tool for ecological research (Jordan *et al.* 1987). Created and restored ecosystems provide unique research opportunities to scientists that natural systems do not, particularly in subjects such as self-organization and ecosystem development (Mitsch and Jorgensen 2004). Monitoring restored coastal areas can provide tools for planning management strategies and help improve future restoration practices and projects (Washington *et al.* 2000).

The research-based mission of the NERRS and the DNERR directly support applying monitoring and scientific research to restoration projects. Restoration project monitoring must be based in scientific testing and experimental design. There is a fundamental need to document baseline conditions of monitoring sites, establish research test plots, identify control areas, and monitor resource conditions over a specified timeframe.

The U.S. Department of Commerce, National Oceanic and Atmospheric Administration has produced several documents that provide guidance and specific protocols for coastal restoration project monitoring criteria. Given the NOAA relationship to the DNERR, following the guidance and framework of these documents is essential for Blackbird Creek Reserve ecological restoration project monitoring. Two key documents that should be used to guide the restoration framework are the *Science-Based Restoration Monitoring of Coastal Habitats Volume 1* (Thayer *et al.* 2003), and *Draft NOAA Fisheries Technical Guidance Manual for Success Criteria in Restoration Projects* (Pinit *et al.* 2000). Both documents emphasize the need to develop scientifically defensible monitoring plans, and every restoration project for the Blackbird Creek Reserve will need to develop one. There are twelve steps, and thirteen specific habitat types (coastal freshwater to marine systems) identified for developing a scientifically based and statistically valid restoration monitoring plan (Thayer *et al.* 2003). The corresponding habitat types are provided in Appendix B. Suggestions for possible monitoring parameters corresponding to each recommended restoration type is provided in Section 4 of this master plan.

4.0 RESTORATION RECOMMENDATIONS

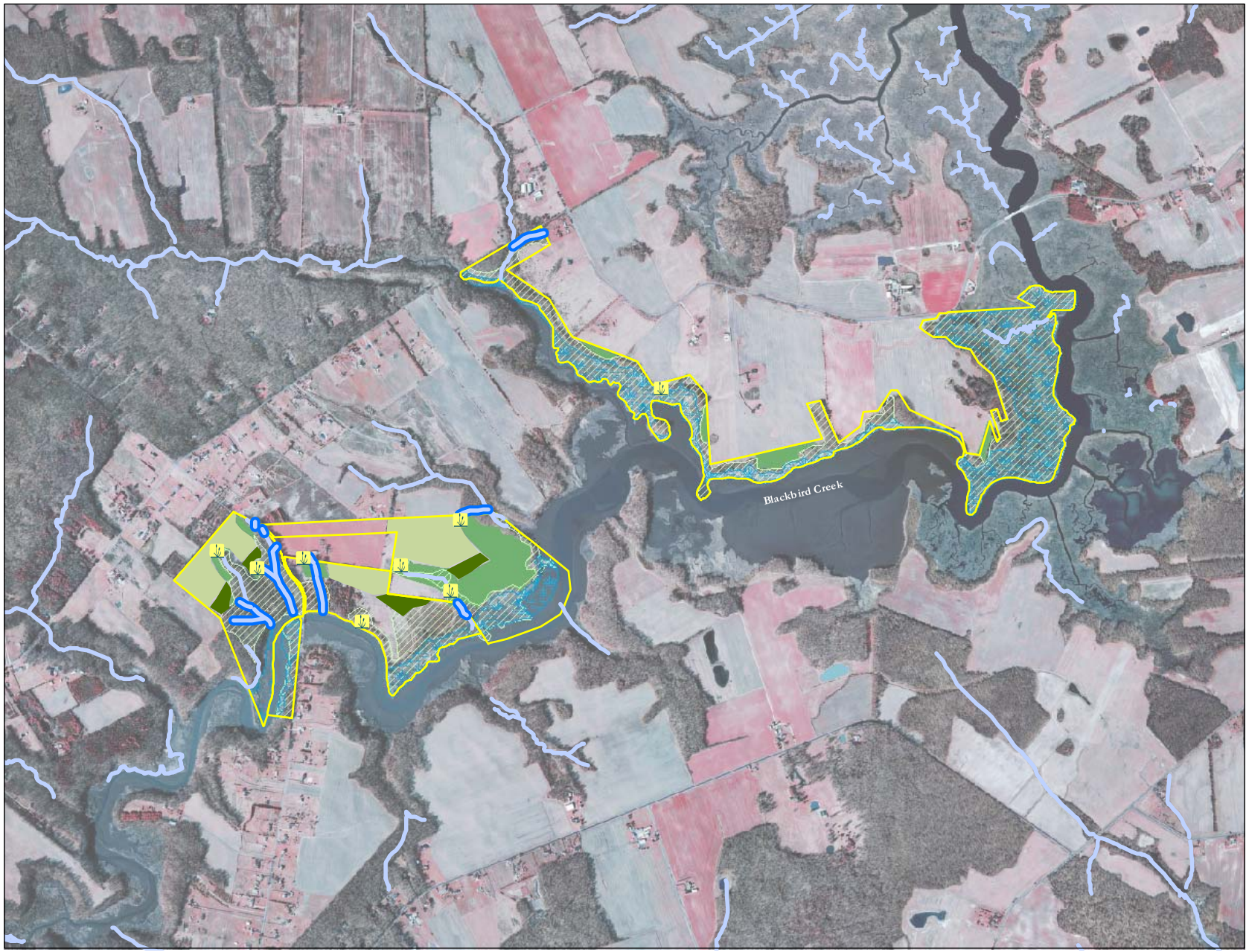
4.1 Restoration Phasing and Priorities

The identification of ecological restoration priorities and phases is important for the short-term immediate needs for Phase 1 (Year 1) and for the longer term Phase 2 (Years 2-5) and Phase 3 (Years 6-15). The prioritization and phasing recommended here is meant for general guidance as a starting point. In the truest sense of adaptive management (learning through implementation, testing and modifying practices) the actual restoration timing, techniques and priorities will and should change over time. This is necessary to account for research and monitoring results for initial efforts, changes in the watershed, related ecosystem function modeling/analysis and available resources (financial and material). Building in the flexibility for changes in acreages, locations and types of restoration projects and approaches is inherent in this ecological restoration master plan.

Restoration needs were evaluated for this project based on site observations and existing information review. The specific restoration recommendations are structured to effectively implement the restoration approach identified in Section 3. A list of priority ecological restoration needs by restoration type is provided below in order of need and importance as recommended by Biohabitats. It is based on GIS information, prior studies, our field reconnaissance and analysis. Priorities were assessed based on a number of considerations applied to each restoration activity type to rank their importance. The results of this screening are provided in Table 4.1. This does not suggest for example that all headwater stream restoration projects and actions need to happen first. Rather, we identified the order of highest priority, with the expectation that elements of each of the restoration type will occur in the near-term and longer term phases. The distribution of recommended ecological restoration types is provided in Figure 4.1. Phase 1 recommendations are shown in Figure 4.2, and Phase 2 & 3 recommendations are in Figure 4.3.

The recommended priority restoration project types are as follows:

- Headwater stream restoration
- Riparian corridor buffer restoration
- Invasive species management
- Wetland restoration—freshwater nontidal
- Wetland restoration—tidal marsh
- Upland reforestation
- Upland native meadow restoration



Blackbird Creek Reserve
Ecological Restoration
Master Plan

Ecological Restoration Recommendations Figure 4.1

Legend

- Blackbird Creek Reserve (DNERR-Owned Parcel)
- Stream Channel

Ecological Restoration Recommendations

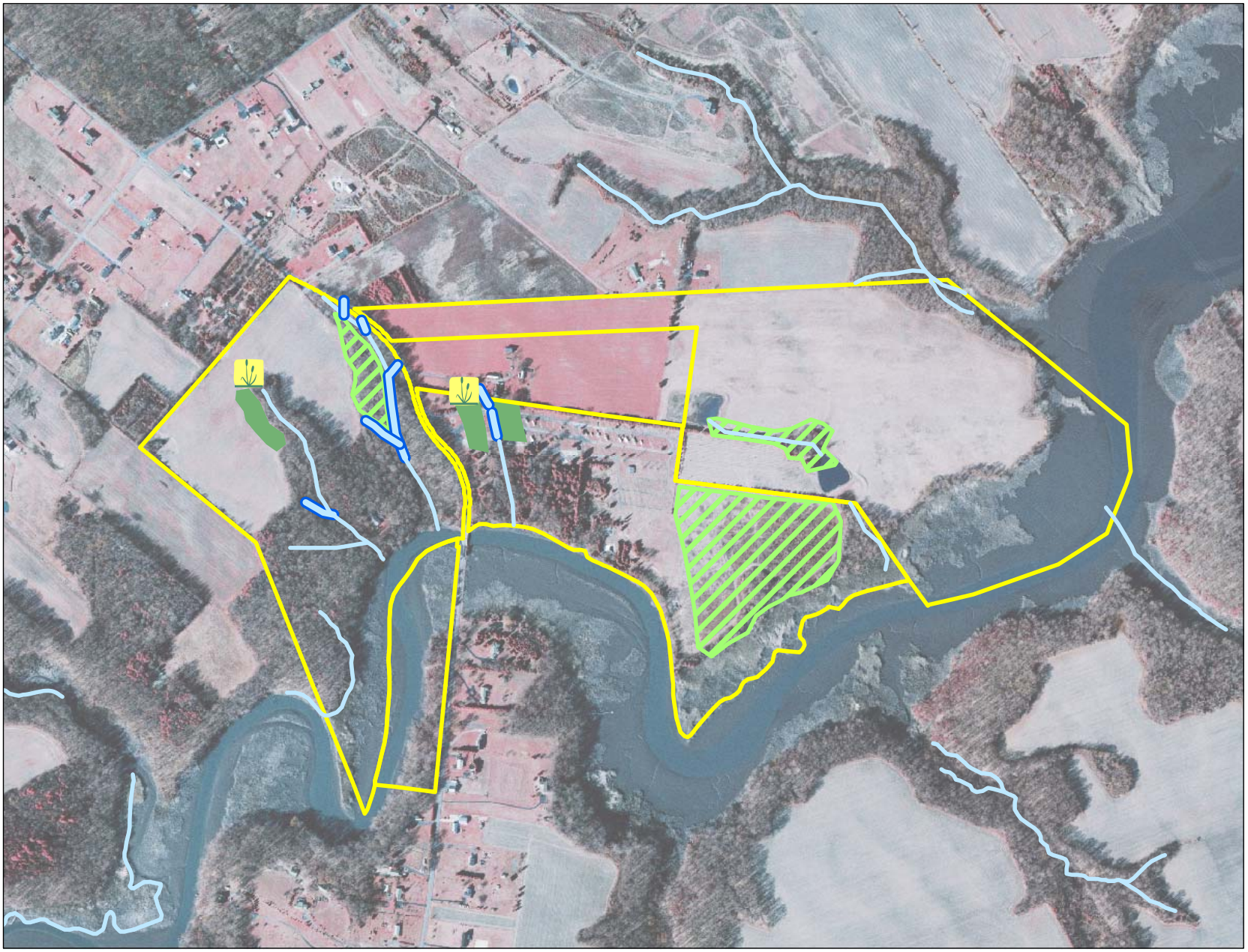
- Headwater Stream Restoration
- Wetland Restoration-Tidal Marsh
- Invasive Species Management
- Riparian Corridor Restoration
- Native Meadow Restoration
- Upland Reforestation
- Wetland Restoration-Freshwater Non-Tidal

DATE: 03/07

Biohabitats

N

0 312.5 625 1,250 1875 2500 Feet



Blackbird Creek Reserve
Ecological Restoration
Master Plan

Phase 1
Ecological Restoration
Recommendations
Figure 4.2

Legend

Blackbird Creek Reserve (DNERR-Owned Parcel)

Stream Channel

Ecological Restoration Recommendations

Headwater Stream Restoration

Invasive Species Management

Riparian Corridor Restoration

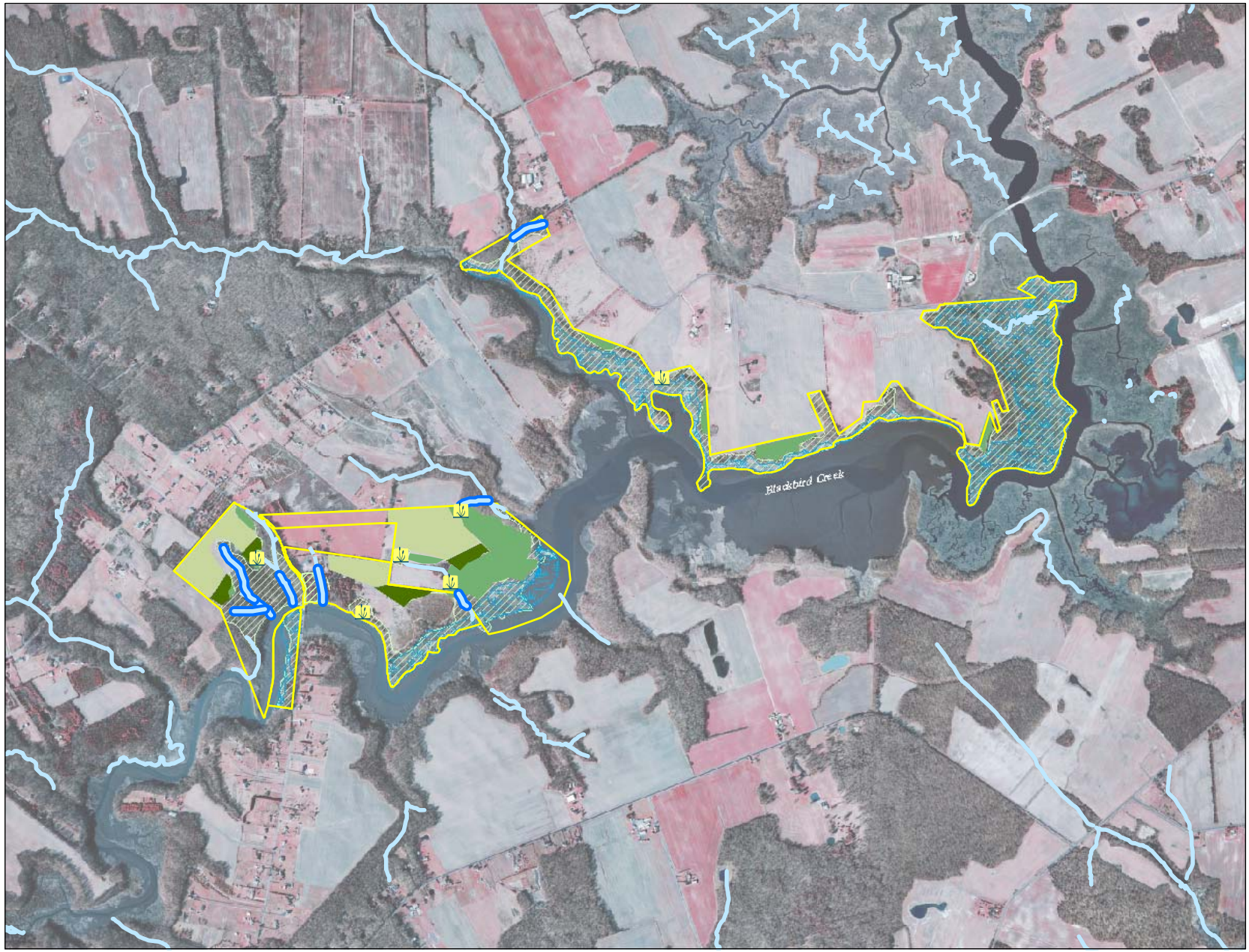
Wetland Restoration-Freshwater Non-Tidal

DATE: 03/07

Biohabitats

N

0 125 250 500 750 1,000 Feet



Blackbird Creek Reserve
Ecological Restoration
Master Plan

Phase 2 & 3
Ecological Restoration
Recommendations
Figure 4.3

Legend

- Blackbird Creek Reserve (DNERR-Owned Parcel)
- Stream Channel

Ecological Restoration Recommendations

- Headwater Stream Restoration
- Wetland Restoration-Tidal Marsh
- Invasive Species Management
- Riparian Corridor Restoration
- Native Meadow Restoration
- Upland Reforestation
- Wetland Restoration-Freshwater Non-Tidal

DATE: 03/07

Biohabitats

N

0 3125 625 1,250 1,875 2,500 Feet

Table 4.1 Restoration Prioritization Considerations

Ranking	Restoration Type	On-going active disturbance	Long-term degradation of resource	Recent acceleration of degradation	Continuation threatens infrastructure	Impacts other resources or areas	NERRS Priority for DNER Reserve	Additional DNERR Priority for tracts	Condition disrupts natural processes	Total
1	Headwater Stream Restoration	•	•	•	•	•		•	•	**7**
2	Riparian Corridor Buffer Restoration	•	•			•		•	•	**5**
3	Invasive Species Management	•	•			•	•		•	**5**
4	Wetland Restoration--Freshwater Non-tidal		•			•	•		•	**4**
5	Wetland Restoration--Tidal Marsh			•			•		•	**3**
6	Upland Reforestation		•				•		•	**3**
7	Native Meadow Restoration		•				•			**2**

The following sub-sections of this plan describe the recommended approach to each ecological restoration type. After the restoration approach is described, the following information is provided for each restoration type:

- Restoration target (amount and type of each ecological restoration measure)
- Focal animal species (representatives from guilds for assemblages habitat is targeted for)
- On-going management needs (short-term maintenance & management necessary to support future restoration)
- Pre-implementation needs/Data gaps (necessary studies, plans or actions prior to implementing restoration projects)
- Monitoring & research needs (types of collaboration, planning and possible parameters to provide research based restoration monitoring)

Table 4.2 identifies the associated restoration actions recommended for each phase of ecological restoration.

Restoration Target Determination

The restoration targets in section 4.2 are based on a combination of on-site resource conditions and extent, opportunities based on the master plan objectives, and applicable literature references. The determination of each recommended restoration target is based on the assessments made for this master plan effort, and are intended to be revised in future phases as restoration efforts are implemented, monitored and the system responses are assessed. This will support an adaptive management approach that targets future restoration efforts based on ecosystem recovery, new system stressors and available resources.

Focal Species Identification

The focal species identified for each restoration type are based on a combination of sources and are representative of the associated habitat/vegetation community types. These sources include prior ecological studies of the Blackbird watershed, species ranges and habitat affinity, professional experience, and specific inclusion of animal species/habitat associations identified in the Delaware Wildlife Action Plan (DNREC 2006).

Table 4.2 Ecological Restoration Implementation Phasing and Actions Schedule

	Restoration Phase and Type	Restortion Target	Refine Existing Management	Pre-implementation Data Collection	Initiate Design and/or Permitting	Develop Monitoring Plan	Construct or Implement Project	Conduct Monitoring and Research	Perform Follow-up Management	
	PHASE 1 (Year 1--2007-2008)									
	Headwater Stream Restoration	1635 Linear Feet	√	√	√	√	√			
	Riparian Corridor Buffer Restoration	725 Linear Feet (2.8 acres)	√	√	√	√	√			
	Invasive Species Management	18 acres of upland, riparian & wetland	√	√		√	√			
	Wetland Restoration--Freshwater Nontidal	1 Acre (including 2 'coastal plain ponds')		√	√	√	√			
	Wetland Restoration--Tidal Marsh	0 acres		√						
	Upland Reforestation	0 acres								
	Upland Native Meadow Restoration	0 acres								
	PHASE 2 (Years 2-5--2008-2013)									
	Headwater Stream Restoration	4280 Linear Feet	√	√	√	√	√	√	√	
	Riparian Corridor Buffer Restoration	1900 Linear Feet (34 acres)	√	√	√	√	√	√	√	
	Invasive Species Management	15-20 acres annually		√		√	√	√	√	
	Wetland Restoration--Freshwater Nontidal	2 Acres (including 6-8 'coastal plain ponds')		√	√	√	√	√	√	
	Wetland Restoration--Tidal Marsh	13 ac. fresh to oligohaline, 5 ac. of brackish, and 6 acres of open water to tidal marsh		√	√	√	√	√	√	
	Upland Reforestation	3 acres			√	√	√	√	√	
	Upland Native Meadow Restoration	23 acres	√	√	√	√	√	√	√	
	PHASE 3 (Years 6-15--2013-2023)									
	Headwater Stream Restoration	0 Linear Feet						√	√	
	Riparian Corridor Buffer Restoration	0 Linear Feet						√	√	
	Invasive Species Management	15-20 acres annually		√		√	√	√	√	
	Wetland Restoration--Freshwater Nontidal	2 Acres (including 6-8 'coastal plain ponds')		√	√	√	√	√	√	
	Wetland Restoration--Tidal Marsh	27 acres fresh to oligohaline and 45 acres of brackish		√	√	√	√	√	√	
	Upland Reforestation	5 acres			√	√	√	√	√	
	Upland Native Meadow Restoration	13 acres	√	√	√	√	√	√	√	

4.1.2 Additional Rare Species Needs & Considerations

Due to the fact that there are identified rare, threatened or endangered species (RTE) identified for the Reserve tracts, and other RTE species may occur, a detailed RTE inventory study is needed. This is necessary in order to specifically understand their extent and to effectively manage this important ecological resource. Specific needs for an RTE species study include the following:

- Conduct seasonal field investigations based on identified and potentially occurring species, their biology, life stages, seasonality and habitat needs
- Document the RTE species population sizes, distribution and condition to provide a baseline for protection, management and monitoring
- Identify direct threats and stresses to the RTE species populations

A comprehensive RTE study will help to inform the specific planning, design, implementation and management of the ecological restoration initiatives and facility/site amenity projects. Most importantly, integrating RTE species considerations into project implementation is intended to help ensure their protection and conservation.

The potential relationship of the currently known RTE species associated with the recommended ecological restoration habitat types identified in this section are:

- Purple milkweed—Upland and riparian forests (low, dry areas of shady woods)
- Large tick-trefoil—Upland forests (high, dry woods, clearings)
- Pale avens—Upland forests (forest openings, and thickets)
- Whorled mountain mint—Native meadow (dry fields/grassland, thickets)
- Long-lobe arrowhead—Tidal wetlands (muddy intertidal flats, water)
- Bald eagle—Riparian corridor buffers and tidal marsh wetlands (forests, bodies of water)

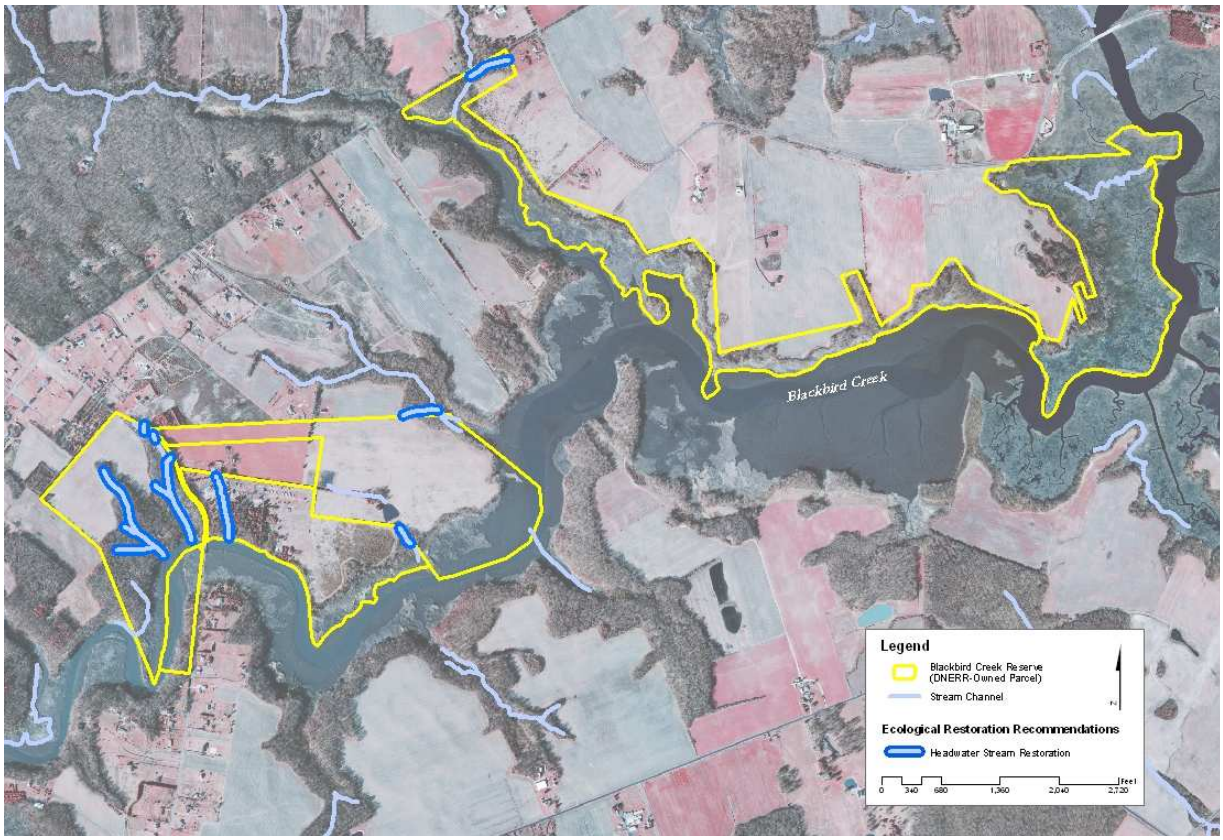
4.2 Recommended Restoration Types

4.2.1 Headwater Stream Restoration

Stream restoration is recommended for all of the degraded headwater stream tributaries. Stream restoration techniques shall target the most severely and actively eroding stream reaches, including first order head cuts (see habitat target and pre-implementation needs) and others based on a geomorphic assessment. The stream restoration approach shall use natural channel design techniques and emphasize the use of on-site native materials (logs, rocks, and vegetation cuttings). The work shall minimize excavation and grading, utilizing strategically placed stream (natural) structures and grade controls. Headwater stream restoration is recommended to occur in conjunction with strategically located headwater wetland restoration or creation. This will be beneficial for run-off interception in the form of hydraulic interruption and habitat features in high run-off agricultural and fallow fields. Stream channel restoration is a high priority for the Cornelius Tract roadside head-cut channels and the Lowe Tract entry area stream.

Restoration Target:

Restore a total of approximately 5915 linear feet of degraded headwater stream channels, approximately 1635 linear feet targeted for Phase 1 (Cornelius head-cut channels and Lowe entry stream), and approximately 4280 LF for Phase 2. The target for stream restoration is developed from a site-specific determination that all the identified degraded headwater stream reaches need to be restored in the near future, before further impacts occur to the stream system or other related ecological resources and infrastructure.



Focal Animal Species for Habitat Type
Bridle shiner (*Notropis bifrenatus*), spotted sandpiper (*Actitis macularia*), and midland clubtail (*Gamphus fraternus*).

On-going Management Needs

Reduce or eliminate the mowing of field edges and agricultural cropping within 100 feet of headwater channels. Consider closing off the trail from fields to house on Cornelius Tract.

Pre-implementation Needs/Data Gaps

- Identify and retain a geomorphologist/stream restoration specialist
- Conduct a geomorphic assessment of all on-site stream channels and further prioritize reach segments for restoration
- Monument stream restoration reach cross sections and record GPS/photo point locations to document current stream conditions.
- Identify a restoration design approach and concept for each reach to be restored.
- Initiate a stream plan design development, acquire regulatory approvals and make construction contracting arrangements.

Monitoring & Research Needs

Identify research partners from local or regional Colleges / Universities, DNREC or other collaborating consultants. Develop a monitoring plan for each stream restoration project. Establish testable hypotheses. Select and monitor appropriate reference sites, and on-site control reaches. Implement a restoration site monitoring plan. Consider the impact of monitoring activities on the habitat and minimize these impacts.

Possible monitoring parameters include:

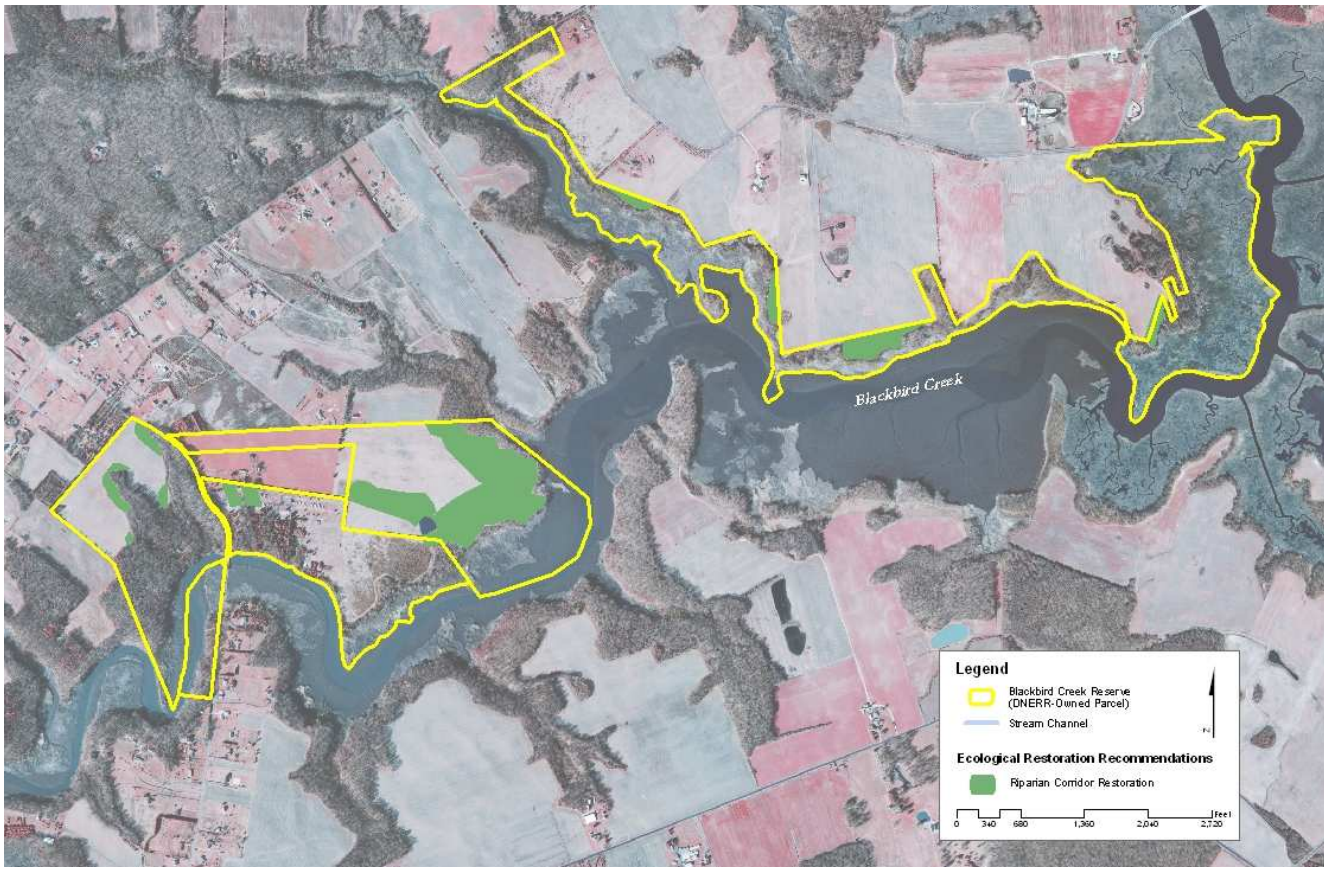
- bankfull width
- sinuosity
- bank full elevation
- bank erosion/scour
- bed characterization/pebble counts
- cross-sectional areas
- wetted width
- channel slope
- floodplain profile
- riparian vegetation
- aquatic organisms (fish and macro-invertebrates).

4.2.2 Riparian Corridor Buffer Restoration

Riparian buffer restoration is recommended for the Blackbird Creek mainstem and all the stream tributaries on the tract parcels. Buffer restoration is recommended in the form of native reforestation plantings and natural succession management where the existing buffer is non-existent, inadequate in width, or poorly structured. In this ecosystem, an expanded forested buffer area is generally recommended (for mesic to dry hardwood forest types) with the potential for minor inclusions of scrub-shrub or limited patches of native coastal plain meadow.

Restoration Target:

Restore a total of 2625 linear feet, approximately 37 acres of creek and stream corridor buffers to riparian forest habitat types. The phase targets are 725 linear feet, 2.8 acres in Phase 1; and 1900 linear feet, 34.0 acres in Phase 2. The riparian buffer target is based on a 300-meter wide (approximately 150m each side) riparian corridor for the mainstem Blackbird Creek and Beaver Branch. The riparian buffer recommendation for the non-tidal stream tributaries is a 100-meter wide (50 meters on each side). Riparian corridor buffer restoration target basis is derived from the recommendations in the Millington-Blackbird Corridor Conservation Area Plan (TNC/DNREC 2005).



Focal Animal Species for Habitat Type

Kentucky warbler (*Oporornis formosus*), evening bat (*Nycticeius humeralis*) and carpenter frog (*Rana virgatipes*).

On-going Management Needs

Maintain limited seasonal mowing of fallow field areas until decisions are made for each buffer segment to: 1) allow natural selection for woodland recruitment; 2) maintain in fallow field condition until future phases; 3) plant with reforestation propagules (tree stock or woody seeds).

Pre-implementation Needs/Data Gaps

- Establish buffer baseline documentation study sites with vegetation plots and GPS/photo point monuments to document current riparian composition, structure, and condition
- Conduct further growing season studies of native species composition, invasive species distribution, propagule sources, and soil analysis samples (to help determine appropriate species locations and potential soil amendment needs)
- Initiate planting plan development and plant source identification

Monitoring & Research Needs

Identify research partners from local or regional College / University partners, DNREC or other collaborating research organizations. Develop a monitoring plan for each riparian buffer project. Establish testable hypotheses. Select and monitor appropriate reference sites, and on-site control sites. Implement a restoration site monitoring plan. Consider the impact of monitoring activities on the habitat and minimize these impacts.

Possible monitoring parameters include:

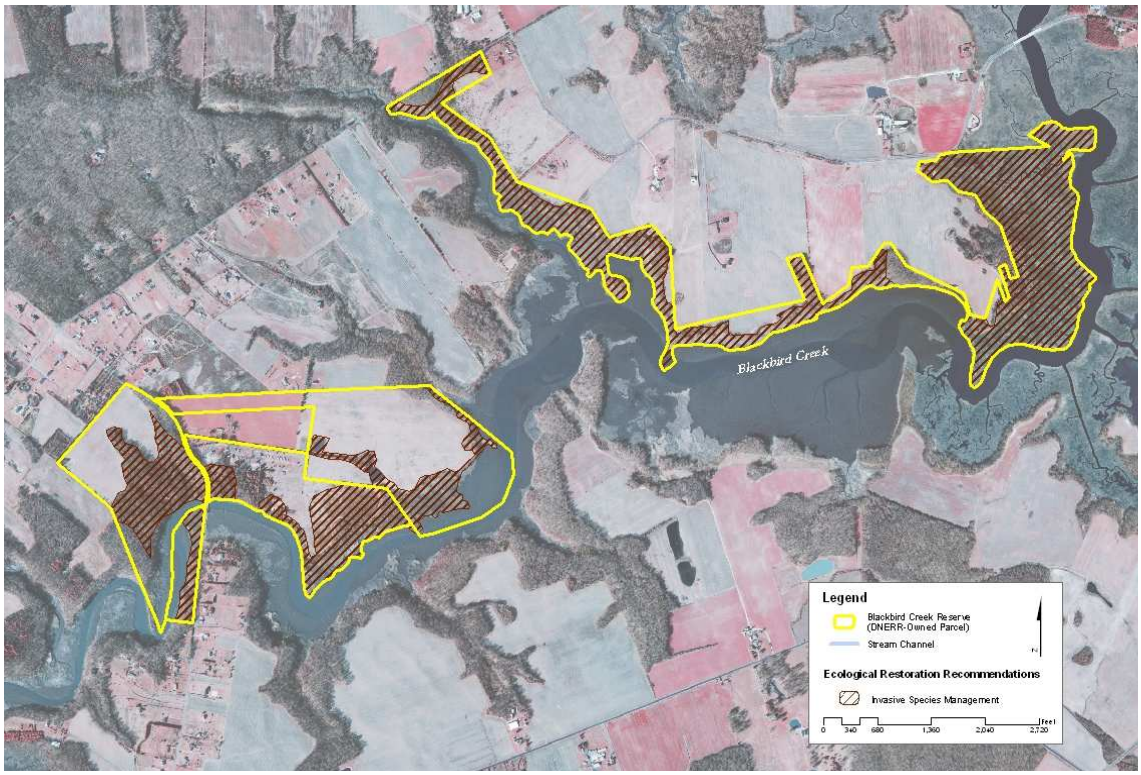
- species composition
- percent cover
- canopy extent
- interspersion
- litter fall
- mast/seed production,
- plant health (herbivory damage, disease)
- woody debris
- animal species (composition and relative abundance).

4.2.3 Invasive Species Management

Invasive species management is needed for all habitat types on the Black Creek Component. Not all invasive species management efforts involve active invasive species treatment, removal and control. Invasive species management includes baseline assessment, monitoring, active control, passive control and combining invasive species management with other types of projects such as stream restoration, wetland restoration and reforestation. Priority non-native invasive species for control are Kudzu (*Pueraria Montana*), Canada thistle (*Cirsium arvense*), and multiflora rose (*Rosa multiflora*). Common reed (*Phragmites australis*) needs to be addressed in a comprehensive long-term fashion, rather than attempts at short-term total eradication, due to it homogenous occurrence throughout the Blackbird Creek tidal marsh system. Further study of the implications of long-term agricultural land nutrient delivery to the marsh and creek system is needed to address common reed persistence and control potential. Recommended invasive species control techniques include stem/stump cut herbicide (non-persistent) treatments, physical manual removal, soil amendments, hydrology manipulation, controlled burning and native plantings.

Restoration Target:

For specific ecological restoration projects and managed areas, control all of the 'priority' species referenced above to < 5% coverage to keep these aggressive species in check. Due to requirements of Delaware's Noxious Weed Law, Canada thistle must be completely controlled (a 0% cover target). For all other existing non-native invasive species, manage for less than 15% total coverage, reflecting a greater tolerance for their occurrence in the system. For all existing community types, provide active control to 18 acres of invaded upland, riparian forests, non-tidal forested wetlands, and tidal marsh edges in Phase 1; and treating 15-20 acres annually in Phases 2 and 3. The targets for invasive species management are based on the biology and character of the species to be controlled, and the practicality of achieving control thresholds.



Focal Animal Species for Habitat Type

Various by habitat, representative species include red-headed woodpecker (*Melanerpes erythrocephlus*), marsh wren (*Cistothorus palustris*), and Cope's gray tree frog (*Hyla chrysoscelis*).

On-going Management Needs

Actively treat any identified occurrences of Kudzu, and control Canada thistle to <5% coverage in fallow fields. Treat all targeted non-native invasive species in existing reforestation areas to < 15% coverage, and monitor for invasion by additional highly invasive species.

Pre-implementation Needs/Data Gaps

- Establish invasive species management research sites (for treatment testing) with vegetation plots and GPS/photo point monuments to document current composition, structure and distribution
- Prepare a Blackbird Component-wide baseline inventory of non-native invasive species occurrence including species composition, dominance, percent cover, and distribution

Monitoring & Research Needs

Identify research partners from local or regional Colleges / Universities, ecological consultants, DNREC or other collaborating research and conservation organizations (e.g., The Nature Conservancy). Develop a monitoring plan for each invasive species management project. Establish testable hypotheses. Select and monitor appropriate on-site controls (in this context- untreated) areas, and treatment sites. Implement a restoration site monitoring plan. Other considerations for common reed control include understanding and addressing long-term and large-scale issues related to agricultural land nutrient transport, hydrologic and sediment dynamics (sea level rise, marsh subsidence, etc.) and changes in the watershed land uses.

Possible monitoring parameters include:

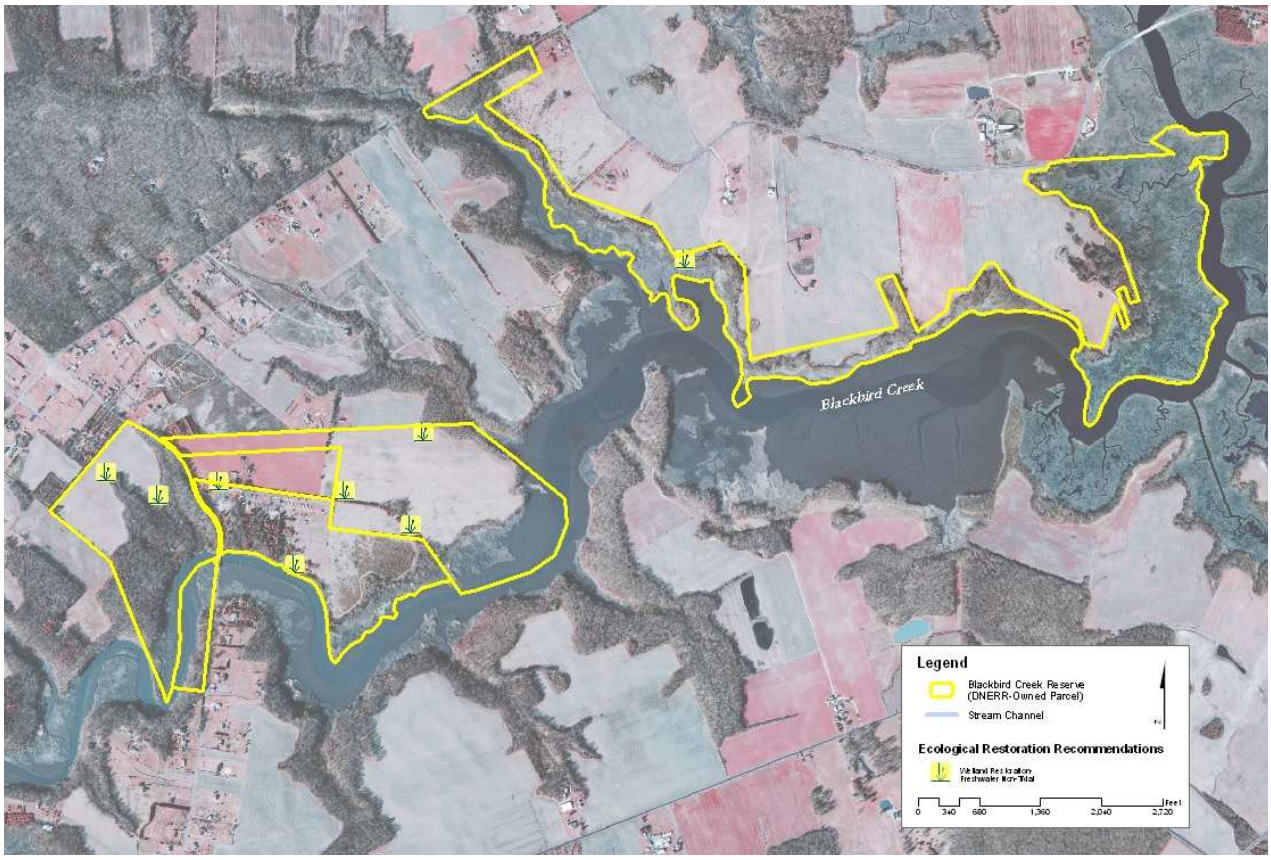
- species composition
- percent cover
- canopy extent
- interspersion
- litter fall
- mast/seed production
- seedling regeneration
- plant health (herbivory damage, disease)
- soil chemistry
- animal species (composition and relative abundance).

4.2.4 Wetland Restoration—Freshwater Non-tidal

Non-tidal wetland restoration is recommended to include 'coastal plain pond' restoration (also potentially involving the conversion of man-made ponds), and the creation of forested or emergent headwater wetlands at headwater streams and in lowing/moist soil areas of agricultural fields and fallow fields. Additional restoration of existing forested non-tidal wetlands primary involves invasive species management and supplemental native planting.

Restoration Target:

Restore a total of 5 acres of non-tidal forested wetlands (Phase 1—1 acre, and Phases2 & 3—2 acres each) at headwater stream locations. Within this forested wetland acreage, create a network of coastal plain ponds to fill in the regional pattern for the Blackbird-Millington corridor at a relative density of 6-8 per 100 acres, corresponding to 14-20 coastal plain ponds (Phase 1—2 ponds, and Phases 2 & 3—6-8 ponds each). Note--one discrete pond complex may be made of many small clustered ponds or 'pools' to achieve this density. The target for the non-tidal forested wetland component includes coastal plain pond wetlands based on a median density derived from TNC/DNREC 2005. Headwater wetlands are targeted for the upper end of each stream to help improve headwater stream conditions at each of these locations on the Reserve parcels.



Focal Animal Species for Habitat Type

Spotted salamander (*Ambystoma maculatium*), Eastern ribbon snake (*Thamnophis sauritus*), and barking treefrog (*Hyla gratiosa*)

On-going Management Needs

Maintain existing pond levels and continue limited seasonal mowing of fallow areas and agricultural field cropping until further study directs most suitable locations for coastal plain pond creation and other forested wetland restoration.

Pre-implementation Needs/Data Gaps

- For the existing man-made ponds and potential headwater wetland areas in agricultural or fallow fields, study and model the hydrology, install and monitor ground-water and surface water monitoring wells
- Perform geotechnical and topographic surveys of each of the restoration sites
- Establish wetland baseline research sites (proposed restoration sites and control sites) with hydrology stations, vegetation plots and GPS/photo point monuments to document conditions
- Initiate wetland plan design development, regulatory approvals and contracting arrangements

Monitoring & Research Needs

Identify research partners from local or regional College / University partners, DNERR, DNREC USFWS or other collaborating research and conservation organizations. Develop a monitoring plan for each wetland restoration project. Establish testable hypotheses. Select and monitor appropriate reference sites, and on-site control areas. Implement a restoration site monitoring plan. Consider the impact of monitoring activities on the habitat and minimize these impacts.

Possible monitoring parameters include:

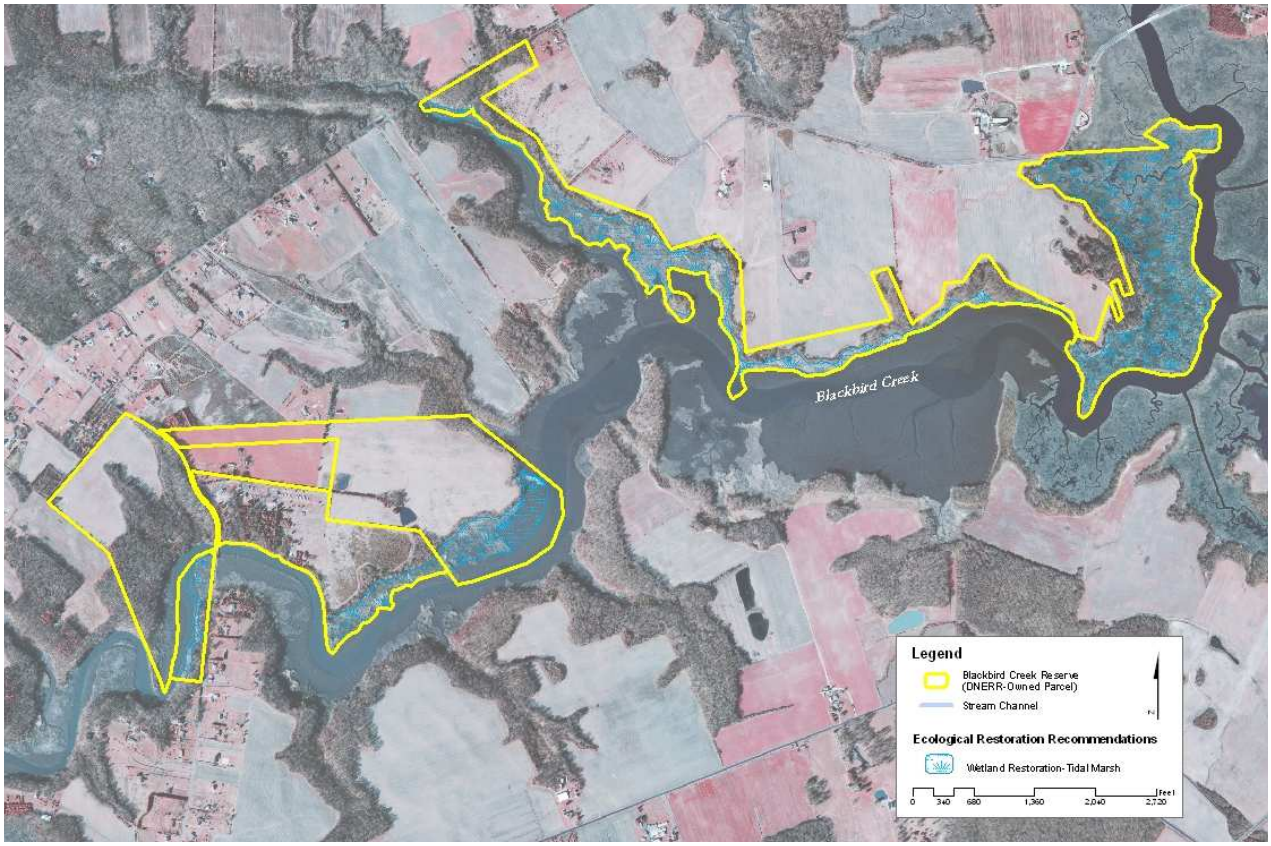
- groundwater and surface elevations
- soil texture, chemistry and nutrients
- sedimentation rates
- vegetation species composition
- percent cover
- canopy extent
- litter fall
- mast/seed production
- plant health (herbivory damage, disease)
- woody debris
- animal species (composition and relative abundance).

4.2.5 Wetland Restoration—Tidal Marsh

Tidal wetland restoration is recommended to include oligohaline to brackish marsh restoration involving a comprehensive strategy, in concert with the other types of restoration and management projects throughout the Reserve lands, to restore their native vegetation composition. Other related elements for wetland system restoration include addressing sea level rise and marsh subsidence in a localized, long term research and monitoring plan. Short-term efforts should focus on the control of non-native invasive *Phragmites* where it is encroaching into other native species dominated marshes. Other possible tidal wetland restoration measures can include sediment dredging and raising marsh surfaces or more passive natural material structures (logs and rock sills) and waterfowl exclusion to increase tidal marsh areas.

Restoration Target:

Restore a total of 40 acres of fresh to oligohaline tidal marsh (Phase 1 –0 acres, Phase 2—13 acres and Phase 3—27 acres); and a total of 50 acres of brackish tidal marsh (Phase 1—0 acres, Phase 2—5 acres and Phase 3—45 acres. Upon further study, there is the possibility for up to 6 acres of additional tidal marsh restoration in the DNERR owned open-water area of the Manwaring Tract (Investigate Phase 1, and implement Phase 2). The target for tidal marsh restoration assumes restoration of a high percentage (about 85%) of the total area of existing tidal wetlands. The restoration of open water to marsh will represent an increase of approximately 6 acres (or about 5% total marsh increase). This will partially help to offset the approximately 148 acre of estuarine emergent wetland loss identified in the Blackbird watershed from 1937-1997 by McCorkle (2000).



Focal Animal Species for Habitat Type

Coastal plain swamp sparrow (*Melospiza Georgiana nigrescens*), black duck (*Anas rubripes*), and northern diamondback terrapin (*Malaclemys terrapin terrapin*)

On-going Management Needs

Continue to keep equipment based maintenance activities out of all tidal wetlands, monitor roadside debris dumping potential Union Church Road crossing at Beaver Dam Creek marsh.

Pre-implementation Needs/Data Gaps

- Record tidal elevation data and pattern at additional Creek and marsh stations (e.g., Beaver Dam Creek, Manwaring shoreline and Lowe shoreline) and analyze tidal hydrology.
- Perform geotechnical/sediment coring study of marsh plain and selected channel bottom substrate to document historic patterns of sedimentation.
- Conduct an inventory and assessment study of native common reed (*Phragmites australis americanus*) stands along the Blackbird Component.
- Establish tidal wetland baseline research sites (proposed restoration sites and control sites) with hydrology stations, vegetation plots and GPS/photo point monuments to document conditions.

Monitoring & Research Needs

Identify research partners from local or regional College / Universities, DNREC, USFWS, US Army Corps of Engineers or other collaborating research organizations. Develop a monitoring plan for each wetland restoration project. Establish testable hypotheses. Select and monitoring appropriate reference sites, and on-site control areas. Implement a restoration site monitoring plan. Consider the impact of monitoring activities on the habitat and minimize them.

Possible monitoring parameters include:

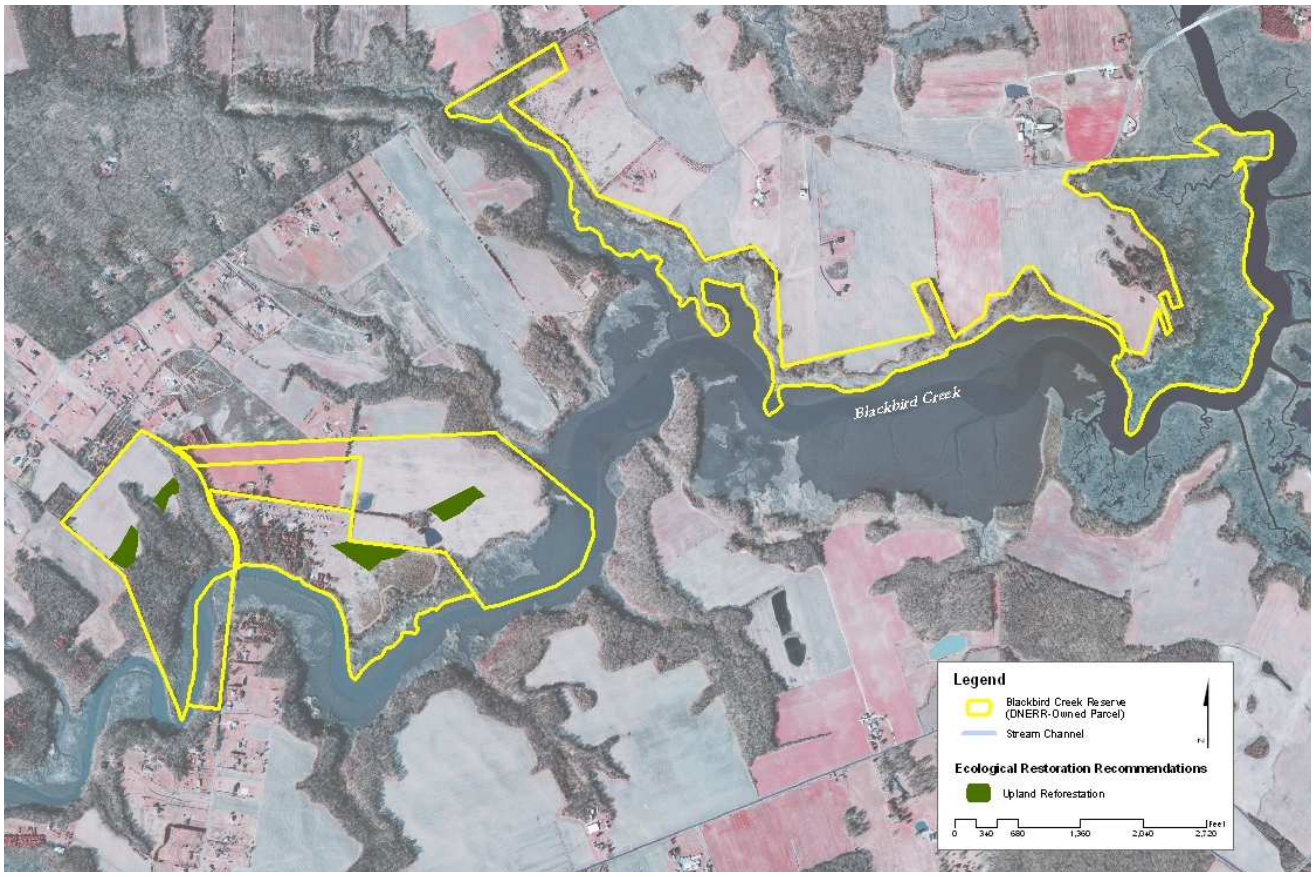
- Tidal elevation ranges and cycle
- marsh substrate texture, chemistry, composition and nutrients
- sedimentation rates (SET, sedimentation elevation tables)
- vegetation species composition
- percent cover
- biomass production
- detritus export
- plant health (herbivory damage, disease)
- animal species (fish, wildlife and invertebrate composition and relative abundance).

4.2.6 Upland Reforestation

Upland reforestation is recommended in addition to the recommendations for riparian buffer restoration reforestation. Additional reforestation is recommended specifically to extend existing blocks of upland forest and to add further buffer area to anticipated wetland restoration and coastal pond creation areas. Reforestation approaches will include various techniques including natural succession management, planting various propagules (seeds, tubelings, bare root plants, container-grown nursery stock), and soil amendments. Reforestation efforts will be integrated with invasive species management measures.

Restoration Target:

Restore a total of 8 acres of upland forest (Phase 1—0 acres, Phase 2—3 acres and Phase 3—5 acres) to include areas in the Cornelius tract agricultural fields, former campground fields on Lowe Tract, and part of the Manwaring Tract fallow fields. The target for upland reforestation is based on increasing the forest patch size on the Cornelius tract from 31 acres to 39 acres, thereby creating a total forest patch of 75 acres when the connected forest area off-site of the Cornelius tract is considered. Increasing patch size and interior forest area is intended to provide additional habitat for some area-sensitive species. There is the potential for the Reserve to convert the remainder (about 13-15 acres) of the Cornelius tract agricultural fields to upland forest to create an approximately 90-acre forest patch (with the possibility for larger areas working with adjacent land owners).



Focal Animal Species for Habitat Type

Wood thrush (*Hylocichla mustelina*), Scarlet tanager (*Piranga olivacea*), and broadhead skink (*Eumeces laticeps*)

On-going Management Needs

Maintain limited seasonal mowing of fallow areas and continue agricultural field use until decisions are made on the exact timing of each upland reforestation planting effort.

Pre-implementation Needs/Data Gaps

- Establish upland reforestation baseline research sites with vegetation plots and GPS/photo point monuments to document current upland forest composition, structure and condition.
- Conduct further growing season study of native species composition, invasive species distribution and propagule sources, and soil analysis samples.
- Initiate planting plan development and plant source identification.

Monitoring & Research Needs

Identify research partners from local or regional College / Universities, US Forest Service, DNREC or other collaborating research organizations. Develop a monitoring plan for each upland reforestation project. Establish testable hypotheses. Select and monitor appropriate reference sites and on-site control sites. Implement a restoration site monitoring plan. Consider the impact of monitoring activities on the habitat and minimize these impacts.

Possible monitoring parameters include:

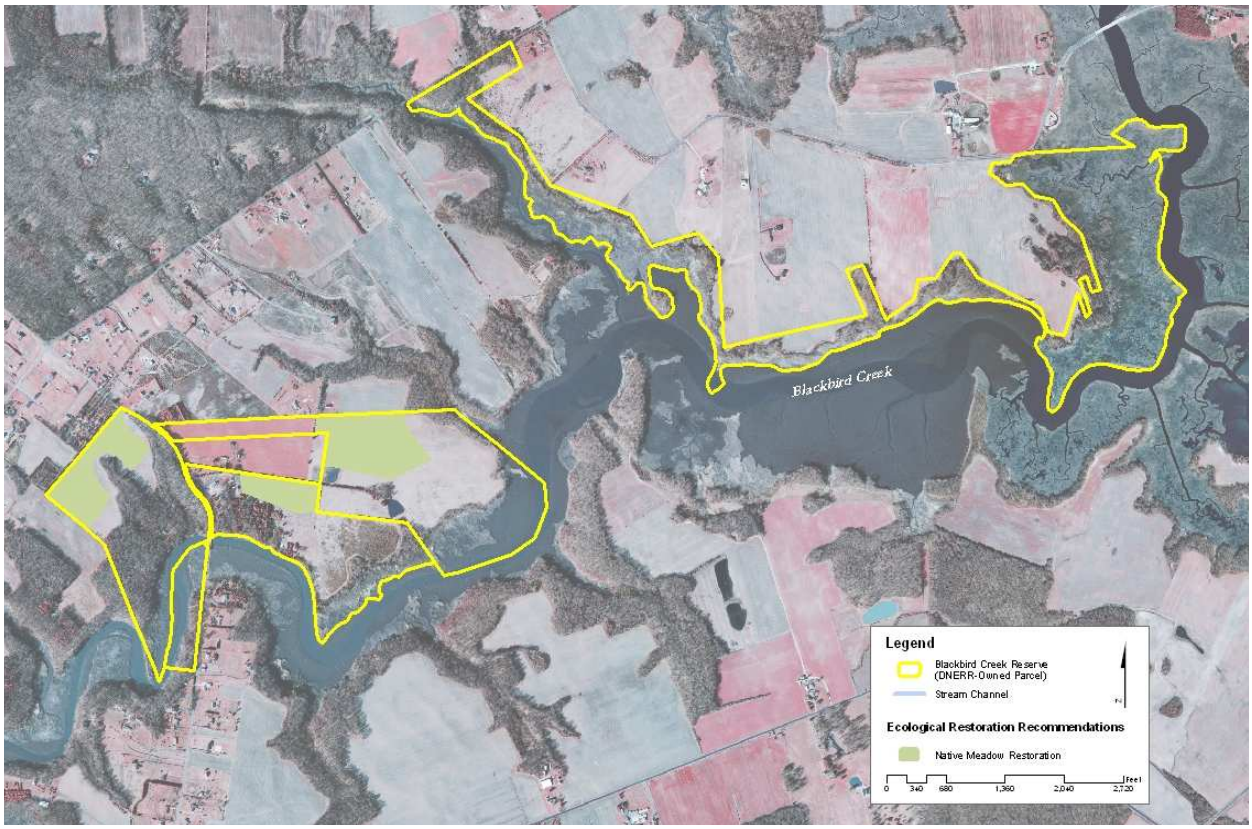
- species composition
- percent cover
- canopy extent
- interspersion
- litter fall
- mast/seed production and seedling regeneration
- plant health (herbivory damage, disease), and woody debris
- animal species (composition and relative abundance).

4.2.7 Upland Native Meadow Restoration

Upland Native Meadow restoration is recommended for a large portion of the currently fallow fields on the Manwaring Tract. This habitat type will add to the diversity and mosaic of habitat types on the Blackbird Component without compromising the intended riparian buffers, wetland restoration or upland reforestation. Native meadow will provide habitat for some niche species including Lepidoptera (butterflies, moths and skippers), small mammals, and non-area-sensitive grassland birds. Native meadow restoration approaches will include non-persistent, targeted herbicide treatment of cool season grasses and weeds followed by drilling seeding native warm season grasses and wild flowers. Other options include allowing natural succession and monitoring weeds or plant invasion potential and treating those invasions by strategic mowing, herbicides or controlled burning.

Restoration Target:

The remainder of the Blackbird Creek Reserve tracts that are not identified for other higher priority restoration types and targets are recommended for upland native meadow restoration. The target is to restore a total of up to 36 acres of upland native meadow including a 6-acre portion of the former campground fields fallow fields on the Lowe Tract, and a 17-acre portion of the fallow fields on the Manwaring Tract in Phase 2 (must be after September 30, 2009 due to Conservation Reserve Program contract), with the potential to also convert a 13-acre portion of the Cornelius Tract agricultural fields in Phase 3. Restoring adjacent areas on the Lowe and Manwaring tracts will establish approximately 23 acres of native meadow. Ecologically, this will provide additional valuable coastal plain habitat in a mosaic with the other habitat restoration efforts, and will support certain grassland dependent plant and animal species.



Focal Animal Species for Habitat Type

Bobwhite quail (*Colinus virginianus*), Eastern box turtle (*Terrapene carolina*) and Meadow fritillary (*Boloria bellona*).

On-going Management Needs

Maintain limited seasonal mowing of fallow areas and continue agricultural field use until decisions are made on the exact timing of each upland reforestation planting effort.

Pre-implementation Needs/Data Gaps

- Establish upland meadow restoration baseline research sites with vegetation plots and GPS/photo point monuments to document current upland forest composition, structure and condition
- Conduct further growing season studies of native species composition, invasive species distribution and propagule sources, and soil analysis samples
- Initiate planting plan development and plant source identification

Monitoring & Research Needs

Identify research partners from local and regional Colleges / Universities, Natural Resources Conservation Service, DNREC or other collaborating research organizations. Develop a monitoring plan for each upland native meadow restoration project. Establish testable hypotheses. Select and monitor appropriate reference sites, and on-site control sites. Implement a restoration site monitoring plan. Consider the impact of monitoring activities on the habitat and minimize these impacts.

Possible monitoring parameters include:

- species composition
- percent cover
- canopy extent
- interspersion
- litter fall
- mast/seed production
- seedling regeneration
- plant health (herbivory damage, disease), and woody debris
- animal species (composition and relative abundance).

5.0 SUSTAINABILITY AND STEWARDSHIP OPPORTUNITIES

5.1 Sustainable Facilities and Infrastructure

The DNERR proposes several new or redeveloped infrastructure projects on the Blackbird Component tracts to support the research, education and public access components of their mission. There are related site suitability and sustainability issues and opportunities associated with these new facilities. A key point DNERR recognizes is that these facilities need to be compatible with and support conservation and ecological restoration efforts on the Blackbird Reserve. General recommendations for addressing sustainability include avoiding the placement of new facilities in sensitive areas including wetlands, streams, riparian buffers, rare species habitat areas, steep slopes or forest interior areas. Additionally, the amount and location of new impervious surfaces need to be carefully considered and minimized to the extent possible. The associated stormwater run-off needs to be managed and reduced by best management practices (BMPs) and sustainable/low impact development (LID) techniques.

Basic principles related to infrastructure facilities sighting include:

- Minimize the overall size/footprint and disturbance of construction
- Avoid impacts to sensitive natural resources (identified above)
- Place facilities in existing disturbed/altered areas (e.g., maintained fields)
- Emphasize the minimization of run-off and design for infiltration

Specific suggestions for sustainability measures for currently proposed facility projects are as follows:

Canoe/Kayak Launch—Lowe Tract

- Locate in area of existing disturbed creek bank edge
- Create launch as carry-in facility with no vehicle access road/ramp
- Avoid nearby rare plant habitat for Purple milkweed
- Stabilize minor eroded bank areas at launch edges (using living shoreline techniques)

Education Pavilion and Rest Rooms—Lowe Tract

- Place in existing maintained grass field at entry area
- Evaluate building a recycled/re-used material structure (e.g., salvaged logs)
- Use composting toilets for rest rooms facilities
- Serve energy needs with all solar power

Parking and Turn-around/Drive—Lowe Tract

- Reduce driveway widths to minimal necessary for buses
- Formalize parking areas on porous paving materials (e.g., modular pavers)
- Add stormwater BMPs—wet or grassed swales, rain gardens, etc.
- Landscape remainder of entry area with native landscaping (demonstration habitat gardens)

Existing House-Future Offices—Cornelius Tract

- Modify existing landscaping/lawn to native plantings for demonstration and interpretation uses
- Create transition zones to woodland to minimize forest gap and diversify edge
- Formalize a small parking area using porous paving materials (e.g., modular pavers or wood mulch)

Entry Drive Access Road—Cornelius Tract

- Stabilize active head-cut channel with natural channel design stabilization as a part of headwater stream restoration
- Reduce (to narrow 4-5 ft. wide stabilized foot path) or eliminate existing drive path to agricultural fields, add supplemental forest plantings
- Create a roadside vegetated swale BMP along the agricultural field side of the road

Research and Interpretive Trails—Lowe and Manwaring Tracts

- Create a trail plan for placement and management
- Employ infrequent periodic mowing of grassed trails
- Future temporary trail placement can be strategic with invasive species control activities and other habitat restoration and research projects
- Place more permanent pedestrian trails in a limited fashion to highlight specific restoration types and interpretive opportunities

Woodland Stream Crossing Path—Cornelius Tract

- Construct stream crossing bridge in conjunction with adjacent headwater stream restoration to minimize disturbance activities
- Minimize width for pedestrian access only (4-5 feet wide), use leaf litter or hardwood mulch path material
- Meander trail route to avoid existing trees and their critical root zones
- Span a wooden (salvaged/recycled) footbridge over stream with no structural support in stream channel

5.2 Supporting Best Management Practices

BMP Opportunities

There are a number of related BMP opportunities for Stormwater and Agricultural BMPs that can work well with the research, restoration, and stewardship objectives of the Reserve. A few suggestions for applicable BMPs are as follows:

- Expanded agricultural field buffer strips (native grasses and legumes)
- Stormwater run-off or treatment wetlands
- Perimeter native grass or wetland swales
- Experimental winter cover crop varieties native/naturalized species for regenerating/improving soils
- Native hayfield testing trials with indigenous species for silage/feed
- Organic fertilizer/organic farming demonstration and monitoring of adjacent natural systems

BMP Monitoring Potential

Along with the research and monitoring based ecological restoration efforts, the establishment of agricultural and stormwater BMPs provides an opportunity for additional monitoring of BMP performance and effects on natural systems. A brief list of possible monitoring parameters is as follows:

- Precipitation and run-off volumes
- Stream flow
- Water quality
  - --Pollutant concentration
  - --Dissolved oxygen (DO)
  - --metals
  - --temperature
  - --nitrogen and phosphorus
  - --Biological oxygen demand (BOD)
  - --Organics/carcinogens/pesticides
  - --total suspended solids
  - --pH
- Influence of BMPs on downstream receiving waters
  - --Biotic communities (fish & invertebrates)
  - --Sediment transport
  - --in-stream water quality
  - --bank erosion
  - --stream flow

5.3 Stewardship Opportunities

There are stewardship opportunities on the Blackbird tracts related to public use and participation, interpretation and education opportunities. A list of suggested potential stewardship opportunities includes:

- School-aged educational opportunities to highlight a different part of the Delaware Estuary (fresh to brackish tidal creek and marsh system) compared to the St. Jones Reserve
- Applied ecological monitoring and research for college/university students to work with DNERR research staff on baseline and restoration studies
- Restoration practitioner training grounds to showcase and demonstrate a variety of applied ecological restoration practices and research results
- Self-guided, or periodically organized (education staff guided)interpretive trail and demonstration potential for natural communities and ecotypes
- Community-based resource for engaging farmers and other land owners to see restoration and BMP practices in action, to apply to their lands

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APPENDIX A

DNERR Management Plan 1993

This Reserve system management planning document established the inclusion of the DNERR in the National Estuarine Research Reserve System (NERRS). This original plan outlined a detailed acquisition agenda and site information for the two Reserve components, the Upper Blackbird Creek Reserve and the Lower St. Jones River Reserve. Plans were made to guide programs for education/interpretation, research, and resource protection through the first five years of operation at the Reserve components.

DNERR Estuarine Profiles, 1999

This technical document was developed as a comprehensive characterization and inventory of existing natural resources and environmental features of the DNERR's two component sites, the Upper Blackbird Creek Reserve and the Lower St. Jones River Reserve. Site specific inventories were carried out between 1993 and 1997 with backround information general to DE estuaries.

DNERR Management Plan 2004-2009

This management plan is the second edition of the management plan and is an addendum to the original plan approved by NOAA and adopted by the DNERR in 1993. The updated plan describes the mission, goals, and objectives of the NERRS and the DNERR, also describing the accomplishments of the DNERR since the 1993 plan. Action plans are articulated for the Reserve's administration; facilities and construction; public access; education, interpretation, and outreach; environmental research and monitoring; and stewardship.

The plan designates the Upper Blackbird Creek component as being primarily protected for research use with public access closely coordinated with the Reserve Manager to reduce the potential for human impact.

DNERR / DNREC. 1995. DNERR Comprehensive Site Description. Phase I – Description / Analysis of Dominant Vegetation / Cover Types.

The Phase I objective was to begin watershed / estuarine characterizations of the Reserve components by mapping and describing the dominant vegetation and cover types within the boundaries and adjacent lands of the two Reserves, upper Blackbird Creek and lower St. Jones River. This study was intended to serve as a baseline for long-term DNERR monitoring work.

DNERR / DNREC. 1995. Final Report - DNERR Comprehensive Site Description. Phase II – Characterization of Finfish and Aquatic Macroinvertebrate Communities and Waterbird Populations.

The Phase II objective was to complete the major natural resource element characterization of each of the Reserve components with finfish, aquatic macroinvertebrate and waterbird community sampling and analysis. This study was also intended to serve as a complimentary baseline to Phase I for long-term DNERR living resource monitoring work.

McCorkle, Richard C. 2000. Land Use / Land Cover Changes and Ecological Health Indicators in the Blackbird Creek Watershed: With Recommendations For Restoration. Master of Science Thesis in the Marine Studies Program of the University of Delaware.

Richard McCorkle's thesis assessed changes in land use and land cover of the Blackbird Creek watershed between 1937 and 1997. This study developed landscape metrics for land cover data to assess landscape

ecological integrity, identified areas with degraded ecological conditions, developed recommendations for ecological restoration, and provided data with the goal of aiding in the setting of priorities by decision makers concerning non-point source pollution control and wildlife habitat restoration efforts.

Among McCorkle's findings over the 60 year span of time was a 12.5% increase in development to 22% of the upland watershed. Cultivated land accounted for 47% of the upland watershed in 1997 but decreased by 16% over the study time period. There was an increase of deciduous forest by 5% accounting for less than 30% of the upland watershed with almost 70% devoted to human uses. Over this time period large areas of tidal marsh converted to open water and mudflats, a 120 ha increase.

Remote sensing techniques were also used to evaluate forest interior habitat availability, riparian forest width and the degree of forest patch isolation with regard to the sensitivity of some bird species to these conditions.

Klemas, V. V. and R. T. Field. 2004. Remote Sensing of Habitat Change at Delaware NERRS Sites. Final Report to DNREC/DSWC, Delaware Coastal Programs/DNEER.

This remote sensing research report utilized Thematic Mapper Images from 1993, 1999, and 2002 to detect and analyze changes in wetland and upland areas around the Blackbird Creek and St. Jones DNERR sites and the Milford Neck Wildlife Area. In the Blackbird Creek study area, large patches of vegetation loss occurred between 1993 and 2002 along the southern bank of the creek east and west of Blackbird Landing. Conversely, there were areas of considerable vegetation gain north and south of Taylors Bridge and along the north bank of the creek east and west of Blackbird Landing. It is stated that the losses are likely related to Phragmites control efforts. Most of the loss and gain occurred between 1993 and 1997.

Non-tidal wetland vegetation losses were also documented along the Delaware 1 construction corridor as well as wetland losses possibly associated with suburban development east of Route 13. Small areas of wetland loss and gain were seen in several farm fields, possibly reflecting a change in crop vegetation cover in farmed wetland areas. Upland land uses also showed considerable change although it was more difficult to interpret because of less significant land-cover definition than wetland signatures.

Valentine, V. J. 2002. Scrub-Shrub/Emergent Wetland Ecotone Migration Along Delaware Tidal Rivers In Response to Relative Sea-Level Change, Natural Impacts, and Human Modifications. Ph.D. Dissertation in the Marine Studies Program from the University of Delaware.

Research by Valentine articulated several factors affecting the migration of the emergent/scrub-shrub ecotone. The interpretation of historic photos showing wetland boundary migration that corresponded with long-term sea-level rise (SLR) over the same time period suggested the strength of SLR in driving ecotone migration. At the Blackbird tributary site it was found that over time ponding and tidal flat creation occurred. The multiple processes of channel straightening and pond/flat creation appeared to work together to flood the ecotone area, killing woody vegetation and displacing the ecotone. It was unexpectedly determined that ecotones along less altered waterways migrated more than those along highly altered waterways. Differences between migration rates at multiple sites suggested that other site specific factors were also influencing migration.

Muskrat and beaver activity, bridge modifications at Blackbird Landing and Taylors Bridges, *Phragmites australis* expansion, and punctuated storm effects are all forwarded by Valentine as possible mechanisms that are influencing the landward movement of the emergent / scrub shrub ecotone.

Non-Native Species at the NERRs

Wasson, K., Lohrer, D., Crawford, M., and Rumrill, S. 2002. Non-native species in our nation's estuaries: a framework for an invasion monitoring program. National Estuarine Research Reserve Technical Report Series 2002:1.

This NERRs technical report helps to define and guide the monitoring of non-native species in U.S. estuaries. Biological invasions by non-native species are considered a medium to high priority concern at most of the NERRs. Over 85 non-native species were identified by the reserve system with 8 species identified as priorities at 3 or more reserves. Monitoring is considered to be essential in the identification, understanding and management of invasions at the reserves. The document highlights the NERR Graduate Research Fellowship Program which recognizes invasions as a priority concern and sees graduate research a useful tool for focusing and funding research into the impact of invasions at NERRs sites.

Silliman, B.R. and M.D. Bertness. 2004. Shoreline Development Drives Invasion of *Phragmites australis* and the Loss of Plant Diversity on New England Salt Marshes. Conservation Biology 18 (5), 1424–1434.

Silliman and Bertness (2004) found a correlation between *Phragmites australis* invasion of coastal New England salt marshes and shoreline development. It was found that shoreline development, defined as the removal of woody vegetation bordering marshes, was correlated with reduced soil salinities and increased nitrogen availability. Freeing the plant community from several limiting factors allows for those species with a competitive advantage, such as *Phragmites*, to emerge and dominate. This suggests that removing woody vegetation bordering marshes facilitates Phragmites invasion by increasing nitrogen availability and reducing soil salinities. With the Upper Blackbird Creek Reserve area maintaining a tidal fresh to middle oligohaline salinity gradient, a likely contributor to *Phragmites* establishment and expansion along the marsh fringe is the increased availability of nitrogen from the dominant adjacent agricultural land use.

Bailey, A.R. 1997. Detecting and Monitoring *Phragmites* Invasion of Coastal Wetlands: A Comparison of Remote Sensing Techniques. Masters Thesis, College of Marine Studies, University of Delaware.

Bailey's thesis targeted the remote detection of *Phragmites* cover changes in the Blackbird Creek and St. Jones Rivers between 1979 and 1993. The study found that *Phragmites* aerial coverage and median patch size in the Blackbird Creek increased over that time period, although the number of patches decreased over the same period indicating that vegetative clonal growth was the primary mode of expansion.

TNC/DE-DNREC. 2004. Blackbird-Millington Corridor Conservation Area Plan. The Nature Conservancy / Delaware Department of Natural Resources and Environmental Control.

The Nature Conservancy (TNC) and the Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife partnered to develop an existing conditions assessment and conservation plan for the future of the Blackbird-Millington Corridor. The State of Delaware recognizes this corridor as one of the most important areas of the state's "Green Infrastructure." The scientific community, local residents, planning agencies and conservation organizations were all coordinated by the TNC to develop this planning and resource conditions document.

APPENDIX B

NOAA Restoration Monitoring Guidance

NOAA restoration monitoring guidance documents (Thayer et al 2003, Pinit et al 2000) identify 13 habitat types for coastal freshwater to marine systems, and their most recent habitat type designations for monitoring are:

- Water column
- Rock bottom
- Coral reefs
- Oyster reefs
- Soft bottom
- Kelp and other macroalgae
- Rocky shoreline
- Soft shoreline
- Submerged aquatic vegetation (SAV; seagrasses)
- Marsh (marine/brackish and freshwater)
- Mangrove swamps
- Deepwater swamps
- Riverine forests

The five habitat types from the list above that generally apply to the Blackbird Creek component tracts are water column, soft bottom, soft shoreline, marsh and riverine forests. First structural and functional characteristics are identified that correspond to the restored habitat type being monitored (e.g., provides breeding grounds, or supports biomass production). Based on the identified structural and functional characteristics of the habitat, specific parameters to monitor are chosen within the general categories of Geographical (acreage of habitat type), Biological (Plants and Animals), Hydrological (Physical and Chemical), and Soil and Sediment (Physical and Chemical). Many examples of specific monitoring parameters are identified in *Appendix II: Matrices of Habitat Characteristics and Parameters* (Thayer et al 2003).