Integrated Natural Resources Management Plan

2019 Update

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NASA LANGLEY RESEARCH CENTER
STANDARD PRACTICE AND ENVIRONMENTAL ENGINEERING BRANCH
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1.0 PURPOSE OF THE PLAN

Integrated Natural Resources Management Plans (INRMPs) are long-term planning documents that are developed to guide federal facilities in the management of natural resources to support the facility mission requirements while protecting and enhancing natural resources for multiple uses, sustainable yield, and biological integrity. The National Aeronautics and Space Administration (NASA) Langley Research Center (LaRC) INRMP provides recommendations, goals, and implementation strategies for management of LaRC's natural resource assets. The INRMP serves as a natural resources planning, budgeting, and coordinating tool which aids in programming future natural resource project requirements and needs. The INRMP also provides documentation of the coordination between NASA LaRC and the appropriate stakeholders in the development and implementation of its natural resources management program. The INRMP functions as both a planning and management tool ensuring that the operations and natural resources conservation at NASA LaRC are integrated and consistent with good stewardship and legal requirements.

Under NASA Procedural Requirements (NPR) 8580.1A, each NASA Center must develop and maintain an Environmental Resources Document (ERD) describing the current environment at that Center. In compliance with this requirement, LaRC maintains an ERD that is updated at least every two years or as major changes in baseline environmental conditions occur. Identifying natural resources management objectives and developing goals and procedures to meet these objectives are not required elements of the ERDs. The purpose of this INRMP is not to replace or substitute the ERD, but strengthen natural resource management on the Center through more specific identification of natural resources management objectives, goals, and programs.

2.0 GENERAL PLAN INFORMATION

2.1 SCOPE

This INRMP addresses natural resources management on those lands at LaRC and near-water bodies that are:

- Owned by the United States and administered by NASA;
- Used by NASA LaRC via license, permit, or lease for which NASA LaRC has been assigned management responsibility; and
- Leased lands at NASA LaRC and areas occupied by non-NASA entities.

The INRMP primarily concerns natural resources management in the undeveloped, natural areas at LaRC, but also applies to natural resource issues in developed areas and recreational areas.

2.2 GOALS AND OBJECTIVES

The INRMP is a long-term planning document that guides implementation of conservation and restoration programs to help ensure support for the facility mission, while protecting and enhancing natural resources and providing a variety of outdoor recreational opportunities for facility personnel.

The overall management objectives are to integrate urban and forest management, fish and wildlife management, land/wetland management, and management for public access to outdoor recreational opportunities, as practicable and consistent with the facility's mission and established land uses.

Specific goals of the INRMP are to:

- Describe the current and future mission and its requirements and constraints on natural resources;
- State the policies, management philosophy, and objectives of natural resources management at LaRC;
- Provide information regarding the existing biological and physical conditions, and the desired future conditions of the facility and the surrounding area;
- Identify key natural resource management issues and concerns at the facility and in the surrounding area;
- Identify and describe projects and management actions required to meet the objectives of natural resources management while ensuring no net loss in the capability of facility lands to support the mission; and
- Identify scheduling priorities and funding opportunities for the implementation of natural resources projects and management actions.

2.3 AUTHORITY, STEWARDSHIP AND COMPLIANCE

Authority for development and implementation of this INRMP is the NASA Policy Directive (NPD) 8500.1, NASA Environmental Management. NPD 8500.1 directs NASA to maintain environmental stewardship of assets, control over environmental responsibilities, and compliance with applicable legal and other requirements. The Sikes Act, as amended, requires military installations to develop an INRMP as an integral part of a natural resources conservation program. Although the Sikes Act and INRMP requirements do not apply to NASA LaRC, this INRMP was developed in reference to the Sikes Act in order to facilitate conservation and rehabilitation of natural resources on Center.

This INRMP strives to ensure that natural resources management considers both compliance requirements and environmental stewardship objectives. Compliance requirements are those that are driven by state or federal regulations, such as the Clean Water Act (CWA), Coastal Zone Management Act (CZMA), Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and Migratory Bird Treaty Act (MBTA); Executive Orders (EOs); and Memoranda of Agreements or Understanding (MOAs or MOUs). Environmental stewardship projects are those that enhance the facility's natural resources, promote proactive conservation measures, and support investments that demonstrate NASA environmental leadership and proactive environmental stewardship.

This INRMP identifies both stewardship and compliance projects that help meet natural resources management goals. However, funding priority may be given to projects that are required to meet the compliance criteria. Stewardship efforts that rely on volunteer labor, partnership programs, or have

available alternate funding sources may be implemented as long as they do not interfere with the mission.

2.4 RESPONSIBILITIES

The Standard Practice and Environmental Engineering Branch (SPEEB) has primary day-to-day responsibility for natural resources management. The SPEEB will identify opportunities for development of cooperative natural resource conservation agreements (memoranda of agreement [MOA] or memoranda of understanding [MOU]) with relevant federal and state agencies or non-governmental organizations.

SPEEB reviews the INRMP every 2-3 years to update as necessary, and submits funding requests to the SPEEB Branch Head for natural resource management projects and activities. The SPEEB Branch Head provides appropriate funding and staffing to ensure implementation of the INRMP, and oversees the management of natural resources.

Additionally, various NASA contractors contribute to the success of the INRMP implementation, such as grounds maintenance and the Center Maintenance, Operations, and Engineering (CMOE) contractors.

2.5 CONDITIONS FOR IMPLEMENTATION AND REVISION

This INRMP is a dynamic, living document intended to be changed as needed through consultation and data sharing with federal agencies, state agencies, civilian groups, and the discovery of new conditions at the Center resulting from daily mission activities. The NASA LaRC Master Plan (https://gis-www.larc.nasa.gov/masterplan/NASA_LaRC_Center_Master_Plan) documents the current state of the Center and establishes the vision and strategy for the future. The INRMP should be made a component plan to the Master Plan; therefore, the INRMP's goals and objectives should be considered and evaluated early in the planning process for projects and mission changes at the Center.

IMPLEMENTATION

The INRMP will be considered implemented when the NASA LaRC SPEEB:

- Actively requests, receives, and uses funds for priority projects and activities;
- Executes priority projects and activities in accordance with goals and objectives identified in the INRMP;
- Has professionally trained natural resources management personnel available to perform the tasks required by the INRMP;
- Reviews the INRMP every 2-3 years to ensure agreement with LaRC's Master Plan; and
- Documents specific INRMP accomplishments undertaken each year.

REVISION

This INRMP is a long-term planning document that requires periodic reviews of management goals and practices in order to provide the opportunity to incorporate new regulations, science and

information, as well as assess the performance of management actions. Periodic reviews conducted by SPEEB personnel and other interested parties will enable project tracking and assessment, and will help facilitate adaptive management. These reviews may be accomplished via correspondence or in a meeting between appropriate parties. The periodic review is to verify the following:

- All compliance-driven projects and activities have been budgeted for and implementation is on schedule;
- All required trained natural resources positions are filled or are in the process of being filled;
- Projects and activities for the upcoming year have been identified and included in the INRMP;
- All required coordination has occurred; and
- All significant changes to the Center's mission requirements or its natural resources have been identified. Additionally, this INRMP should be reviewed, and if necessary, revised at intervals of not more than five years. However, LaRC is not legally required to institute a formal review every five years. Significant changes to the Center's mission requirements or its natural resources would warrant an INRMP revision.

3.0 LARC'S ENVIRONMENTAL PROGRAM

It is LaRC policy to protect and enhance the quality of the environment through compliance with federal, state, and local regulatory authorities; Executive Orders; and NASA and LaRC policies and directives. Located in the ecologically sensitive Chesapeake Bay watershed, LaRC is committed to fulfilling its mission in a manner that promotes environmental stewardship, sustainability, and continual improvement, while mitigating environmentally driven mission risks.

The LaRC Environmental and Energy Program is managed by SPEEB within the Center Operations Directorate (COD). Environmental staff are responsible for LaRC's environmental compliance, management, and sustainability programs. These responsibilities include coordination and integration of all environmental programs, interpreting environmental regulations, acting as the formal point of contact with all environmental regulation agencies, development assistance and review of environmental permits, remediation of contaminated sites, cease and desist authority for all polluting activities, and compliance monitoring and surveillance.

Environmental staff are also responsible for the management of LaRC's Energy and Water Conservation Program, which provides the focus to achieve energy efficiency and water reduction goals while improving the Center's facilities, reducing utility costs, and increasing employee awareness. Environmental staff assist LaRC in pursuing and implementing cost-effective energy efficiency and water conservation practices.

The environmental program at LaRC includes the following media areas: environmental management system (EMS), sustainability and pollution prevention, energy and water conservation, waste management and disposal, air management and permitting, water management and permitting, hazardous material management and reporting, storage tank management and spill

prevention/response, NEPA conformance, cultural and historic resource management, environmental restoration and remediation, recycling and reuse programs, environmentally preferable purchasing, and natural resource management. Additional information regarding NASA LaRC's Environmental Program can be found on LaRC's public environmental website at: https://environmental.larc.nasa.gov.

NATURAL RESOURCES COUNCIL

Much of NASA's work occurs on federal property at its 13 Centers and Facilities. Each Center is situated amongst unique natural environments that represent many of the Nations' ecosystems. Natural Resource Managers across the agency work to achieve regulatory compliance, protection of species, effective habitat management, and overall improvement of natural resource conditions. Natural Resource Managers from different Centers collaborate regularly to share implementation strategies, identify opportunities, and learn from one another.

The Natural Resources Council (NRC) serves as an advisory and information-sharing body to the NASA Environmental Management Division (EMD). The NRC supports the development of natural resource conservation policy and leadership strategy, drives consensus of priorities across Operational and Mission Directorates, and recommends initiatives to beneficially improve NASA's impact on the Nation's natural resources. The NRC supports NASA's compliance with federal natural resource laws, such as the Endangered Species Act, by developing best practices, recommendations, and guidance. The NRC webpage can be found at https://www.nasa.gov/emd/nrm. Centers can provide updates to the NRC on initiatives that can be highlighted at the site. Natural Resource Managers from different Centers can collaborate through NRC's Sharepoint: https://explornet.nasa.gov/groups/naturalresourcescouncil. By working together, NASA is able to continue pursuing its space and aeronautics mission while managing natural resources to protect the environment.

4.0 LARC'S OPERATIONS AND ACTIVITIES

Research and development activities at LaRC support the Agency's vision, mission, and strategic goals. Detailed information on LaRC's research and development programs and activities is maintained by the Center Master Planner.

LaRC's facility and infrastructure activities are focused on implementing a major 20-year revitalization strategy called ViTAL (Vibrant Transformation to Advance LaRC). The overarching goal is to enhance the Center's core capabilities, reduce the Center's footprint, and transform the remaining infrastructure to be energy efficient, sustainable, and adaptable to changing missions and societal needs. The ViTAL Program includes six new, state-of-the-art facilities, renovation of critical infrastructure, and demolition of non-essential assets. The ViTAL Program will enable NASA LaRC to respond to the strategic and infrastructure challenges of the Agency while making the Center more efficient to operate. The ViTAL Program will create a centralized "downtown campus" area and demolition activities will create additional open space. It is anticipated that there will be a net long-

term positive impact on local wildlife and natural vegetation as removal of facilities and infrastructure will result in more open green space at the Center. The 20-year revitalization plan has been institutionalized in the Center's Master Plan.

The environmental impacts of the ViTAL Program were analyzed in the Environmental Assessment (EA) for LaRC's Master Plan, June 2013. Appendix A of the EA contains the list of proposed projects and activities associated with the 20-year revitalization initiative. The EA is available at: https://sites-e.larc.nasa.gov/environmental/files/2013/08/Final-Master-Plan-EA-6-4-13.pdf

5.0 INTEGRATED NATURAL RESOURCE PLANNING ELEMENTS

This section provides information on each resource area to include a brief description of current conditions, management goals, mission and management issues, recommendations and guidelines, and monitoring. More detailed information on the description of current conditions for each resource area is contained in LaRC's Environmental Resource Document (ERD). The ERD is available at: https://environmental.larc.nasa.gov/nepa/.

A full list of NASA LaRC's flora and fauna is found in Appendix II. The species listed are based on the 2009 "NASA Langley Research Center Habitat Classification and Wildlife Survey Report" by Science Applications International Corporation (SAIC), and the 1995 "Baseline Biological Survey of Terrestrial and Aquatic Habitats at NASA Langley Research Center, With Special Emphasis on Endangered and Threatened Flora and Fauna" by Old Dominion University (ODU).

5.1 BIRD MANAGEMENT

NASA LaRC is located in the Coastal Plain of southeastern Virginia. The predominant ecological feature of this region is the Chesapeake Bay. With its extensive open-water areas and associated tidal flats, creeks, and marshes, the Chesapeake Bay is a major migratory flyway and provides important waterfowl nesting and wintering habitat. Two designated preservation areas in the vicinity of LaRC are the Plum Tree Island National Wildlife Refuge in the City of Poquoson and the North End Point Natural Preserve in the City of Hampton. There are no designated conservation areas on LaRC property.

In 2008, the US Fish and Wildlife Service (USFWS) released 'Birds of Conservation Concern' (BCC) in a continuing effort to assess and prioritize bird species for conservation purposes. BCC are a subset of protected birds under the MBTA and include all species, subspecies, and populations of migratory nongame birds that are likely to become candidates for listing under the ESA without additional conservation actions. An online version of the document is available at https://www.fws.gov/migratorybirds/pdf/management/BCC2008.pdf. This document can be used as a barometer of the condition of the country's avifauna. Although there are general patterns that can be inferred from this report, there is no single reason why any species was placed on any one of these lists; some are relatively common but undergoing sharp declines in population numbers, others are rare but may actually be increasing in numbers in certain locations, and others may be both rare and

declining. Birds included in the BCC 2008 lists are deemed priorities for conservation actions, and the lists will be consulted for actions taken on federal lands in accordance with Executive Order 13186, “Responsibilities of Federal Agencies to Protect Migratory Birds”. BCC species will also receive priority attention in the USFWS when allocating research, monitoring, and management funding. NASA LaRC is located in Bird Conservation Region (BCR) 30 – New England/Mid-Atlantic Coast. Forty-five (45) bird species are listed for Region 30.

Numerous species of birds, including waterfowl and wading birds, use the coastal marshes for foraging and/or roosting such as herons, egrets, ducks, gulls, and geese. Bird species observed at LaRC are based on the 2009 “NASA Langley Research Center Habitat Classification and Wildlife Survey Report” by Science Applications International Corporation (SAIC) and/or the 1995 "Baseline Biological Survey of Terrestrial and Aquatic Habitats at NASA Langley Research Center, With Special Emphasis on Endangered and Threatened Flora and Fauna" by Old Dominion University (ODU). A total of 25 avian species were observed at NASA LaRC during the SAIC survey in 2009. During the 1995 survey by ODU, 118 species of birds were observed. None are federally listed as threatened, endangered, or species of concern. Twelve (12) species observed at NASA LaRC during the ODU (1995) and/or the SAIC (2009) surveys are currently state-listed threatened or BCC species: Bald eagle (*Haliaeetus leucocephalus*), Pied-billed Grebe (*Podilymbus podiceps*), snowy egret (*Leucophoxy thula*), solitary sandpiper (*Tringa solitaria*), lesser yellowlegs (*Totanus flavipes*), least tern (*Sterna albifrons*), gull-billed tern (*Sterna nilotica*), wood thrush (*Hylocichla mustelina*), blue-winged Warbler (*Vermivora pinus*), prairie Warbler (*Dendroica discolor*), worm-eating Warbler (*Helmitheros vermivorus*), and Henslow’s Sparrow (*Ammodramus henslowii*). Although not sited during the ODU survey of NASA LaRC, the peregrine falcon (*Falco peregrinus*), another State-listed threatened species, was sited at adjoining Langley Air Force Base (LAFB) during a survey of the base in 1994 (Geo-Marine, 1994). The gull-billed tern, and the Henslow's sparrow were determined to be transient migrants who use the NASA LaRC facility solely as a foraging stop. A complete list of bird species observed at LaRC can be found in Appendix II.

There is an active bald eagle (*Haliaeetus leucocephalus*) nest on the LAFB approximately 0.5 miles from the NASA LaRC property boundary. According to The Center for Conservation Biology Eagle Nest Locator webpage (https://ccbbirds.org/what-we-do/research/species-of-concern/virginia-eagles/nest-locator/), the nest was last checked and determined active and/or occupied in 2016. There are several active osprey nests on the property boundary as well and are commonly spotted on the top of large trees, utility poles, and research structures at LaRC. Therefore, it is likely that bald eagles and ospreys may hunt prey on the NASA LaRC property and the creation of additional grass areas would create more habitat to support prey species of the bald eagle and any other predatory birds that may be in the area.

An overview of the MBTA, and the Bald and Golden Eagle Protection Act (Eagle Act) can be found in Section 5 of the ERD.

5.1.1 MANAGEMENT GOALS AND OBJECTIVES

The overall goal is to strive to protect and enhance avian resources to the maximum extent practicable. Specific goals include the following:

- Maintain and enhance habitat for resident and migratory bird species.
- Increase bird habitat through management practices to encourage new species.
- Partner with LAFB in bird management programs such as Bird/Aircraft Strike Hazard (BASH) initiatives, osprey counts and relocation, Bald Eagle management, etc.
- Increase awareness and education of migratory bird species found at LaRC.

5.1.2 MISSION AND MANAGEMENT ISSUES

The following is a list of the most pressing bird-related management issues.

- No current efforts for encouraging bird species of concern to LaRC;
- LaRC has issues with birds nesting in buildings, vent stacks, and structural eaves;
- Mowing of potential bird habitats through a lack of coordinated and planned seasonal mowing activities.

5.1.3 GUIDELINES AND RECOMMENDATIONS

BALD EAGLES

The bald eagle (*Haliaeetus leucocephalus*) is protected by the MBTA and the Eagle Act. The MBTA and the Eagle Act protect bald eagles from a variety of harmful actions and impacts. Bald eagles are attracted to freshwater areas and forested upland communities. Eagles are unlikely to be disturbed by routine use of roads, homes, and other facilities where such use pre-dates the eagles' successful nesting activity in a given area. Therefore, in most cases, ongoing existing uses may proceed with the same intensity with little risk of disturbing bald eagles. However, some intermittent, occasional, or irregular uses that pre-date eagle nesting in an area may disturb bald eagles.

In the event that an eagle roost area becomes established at NASA LaRC, signs should be placed at a distance of 200 yards from the roost advising people to remain clear of the area and further coordination with the US Fish and Wildlife Service (USFWS) and the Virginia Department of Game and Inland Fisheries (VDGIF) should occur to ensure all conservation recommendations are being followed. To avoid disturbing nesting bald eagles, the VDGIF Management of Bald Eagle Nests, Concentration Areas, and Communal Roosts in Virginia: A Guide for Landowners (2012)ba recommends (1) keeping a distance between the activity and the nest (distance buffers); (2) maintaining preferably forested (or natural) areas between the activity and around nest trees (landscape buffers); and (3) avoiding certain activities during the breeding season. The buffer areas serve to minimize visual and auditory impacts associated with human activities near nest sites. Ideally, buffers would be large enough to protect existing nest trees and provide for alternative or replacement nest trees.

An active eagle nest is a nest that is attended, built, maintained, or used by a pair of bald eagles during a given breeding season, whether or not eggs are laid. The closest active nest is located in the marsh area over 0.5 miles from the NASA LaRC property. Human activities can affect the nesting, mating, roosting and foraging habitats of the bald eagle and the introduction of a new nesting pair would be unlikely due to the territorial nature of the existing pair. Furthermore, the introduction of large bird species may conflict with the implementation of BASH initiatives on LAFB. Therefore, the attraction of bald eagles to the NASA LaRC property is not encouraged.

OSPREYS

Ospreys are protected under the MBTA. It is unlawful to take, kill, or possess any osprey, including nests and eggs. Osprey nests are commonly found around LaRC and can disrupt operations or research missions if there are eggs or young osprey present in the nest. Osprey nests can be removed without a permit if the nest is inactive. An inactive nest is defined as a nest without any eggs or dependent (flightless) young, and includes nests under construction. A nest is considered active only when eggs or young are present, and removal of such requires a permit from USFWS. In most instances, osprey nests are considered inactive from September 16 through April 1. Any osprey nest that threatens LaRC activities should be reported to SPEEB once discovered to assess status of the nest, and determine subsequent actions.

NESTING BOXES

Declining populations of bird species limited by suitable nesting habitat can be aided with artificial nesting boxes. Eastern bluebirds and American wood ducks are two species that readily use nesting boxes. More information can be found in the project specific recommendations in Appendix I.

ENCOURAGING OTHER BIRD SPECIES

The following suggestions can be used on open grass field areas to improve avian habitat while minimizing the need for continued maintenance mowing of these areas. The following is a list of strategies that could be employed:

- **Keep alert for grassland birds nesting in grass areas.** Mowing around areas where birds are frequently seen or leaving small patches unmowed can easily protect many nesting birds. Small unmowed patches will provide cover and feeding areas for birds for the remainder of the summer.
- **If possible, defer mowing until near the end of the grassland bird breeding season** (i.e. April 15 through August 15 for most species in Virginia) on areas not immediately adjacent to developed areas or areas that would not interfere with the day to day operation of NASA LaRC. This includes areas such as edge habitats adjacent to woody areas, weedy areas, etc.
- **Flushing bars** might possibly be utilized on mowing equipment to move birds hiding in the grass.
- **Avoiding nighttime mowing** will reduce the risks of injuring roosting birds.
- **Raising mower blades to six inches or more** may avoid crushing some nests and young.

- **Local bird clubs or conservation organizations** can help determine where and what birds are nesting in open grass areas on NASA LaRC. Careful observations can determine the approximate nest locations and when birds have successfully raised their young.
- **Reduce or eliminate mowing in natural areas altogether.**
- **Restrict tree removal and ground clearing activities** and adhere to a time-of-year restriction from March 15 through August 15 of any year to protect nesting resident and migratory songbirds.

REFORESTATION ACTIVITIES

Since 2009, LaRC has reforested 1.5 hectares (3.6 acres) with a mix of native hardwoods and pines. Many of these trees are strategically planted in areas around LaRC's nearby waterways. The trees act as riparian buffers to protect local waterways and provide valuable habitat. Furthermore, these projects are an inexpensive way for LaRC to earn "credits" toward pollution reduction goals for the Chesapeake Bay TMDL. Additional reforestation efforts are planned in the future in order to maximize groundwater absorption, improve water quality, and expand forested habitats.

When reforesting areas at LaRC with hardwood seedlings, all bare-root seedlings should be protected with a solar tree tube to protect the seedling during early growth. Additionally, the tree tube should have bird exclusion netting across the top of the tube to prevent birds from being trapped within the tubes.

5.1.4 MONITORING

The introduction of large populations of any bird species may conflict with the implementation of BASH initiatives on LAFB. Therefore, it is recommended that NASA LaRC work closely with LAFB to ensure that any efforts to attract birds to the installation will not be in direct conflict with the BASH initiative.

When establishing a bird monitoring program it is important to be consistent in the timing of the survey or monitoring on a yearly basis. Monitoring techniques should be consistent and plots should be randomly selected if possible. In the case of any endangered and threatened species on site, all individuals are monitored. In the case of high use areas and high disturbance areas, more frequent monitoring may be warranted during the breeding season. Wintering species should be monitored at least twice a month. It is recommended that fall and spring migrating species should be monitored at least once weekly.

An inexpensive method to conduct monitoring to document presence and use by protected avian species is through partnering with local birding groups. These groups are made up of diverse and motivated individuals from academic institutions, retirees, and may include NASA employees interested in the protection of birds. Through partnerships with these groups and allowing access to NASA LaRC, the Center can obtain regular monitoring reports of species counts, diversity, nesting areas, and potential conflicts.

5.2 DEER MANAGEMENT

White-tailed deer (*Odocoileus virginianus*) is the most abundant large herbivore in the U.S. Deer require adequate food, water, cover, and living space for healthy survival. There are limits to the number of deer that a given area can support. The number of deer in good health that a given area can support is referred to as Biological Carrying Capacity (BCC). The Cultural Carrying Capacity (CCC) is defined as the maximum number of deer that can coexist compatibly with the local human population. The CCC is exceeded when humans complain of excessive deer-vehicle collisions, agricultural damage, or homeowner garden damage. If deer become overpopulated, overbrowsing will occur, which will result in a decline in the health of the deer herd. The potential for deer populations to exceed CCC and to conflict with the well-being of other animal and plant species requires efficient and effective deer management (Northeast Deer Technical Committee 2009).

NASA Langley receives population estimates from deer surveys conducted by the United States Department of Agriculture (USDA) and LAFB. Population estimates range between 300 to 600 deer, annually.

5.2.1 MANAGEMENT GOALS AND OBJECTIVES

White-tailed deer are a familiar and integral part of the LaRC campus area. The overall goal is to strive to protect and ensure a healthy deer population to the maximum extent practicable. Specific goals include the following:

- Promote and ensure a healthy population of deer on Center;
- Ensure deer have adequate habitat resources to limit their use of the central-urbanized area of the Center; and
- Avoid human interaction as much as possible.

5.2.2 MISSION AND MANAGEMENT ISSUES

The presence of white-tailed deer on NASA LaRC property does not appear to be a nuisance issue at this time. However, the following is a list of the most pressing deer management issues:

- Deer and auto collisions represent a Center safety management issue;
- In general, the average deer on Center appears undersized and very slim. The health of LaRC's deer herd is a concern;
- Potential for ticks and Lyme's Disease transmission. Currently, LaRC has little information on the abundance of ticks and/or the potential for Lyme's Disease transmission on Center;
- Shared property boundaries with no fence line require collaboration between LaRC and LAFB for management of the deer population; and
- LaRC has been allocated a bacteria load reduction for the Back River TMDL where wildlife represents the main source of bacteria.

5.2.3 GUIDELINES AND RECOMMENDATIONS

The following are a list of possible management strategies that LaRC could utilize for deer management.

FENCING AND REPELLENTS

Fencing and repellents can address site-specific issues, but economic and aesthetic considerations typically restrict the use of these techniques. Woven wire fences are adequate deterrents, as well as several types of electric fencing. An eight-foot woven wire fence costs ~$6-8 per foot to install. Effective repellent programs require frequent applications and may damage local plants. Repellents vary in cost from $25-45 per gallon, which would treat ~200 small trees or shrubs. Additionally, tree tubes can be utilized to protect young vegetation and tree seedlings. These tools may reduce deer-vehicle collisions or impacts on a particular area, but they do not address deer abundance.

FERTILITY CONTROL AGENTS

While advances in technology have allowed for the use of immunocontraception in deer, this option has a high cost (~$1000 per deer), and requires extensive identification and monitoring of treated individuals. Some fertility control agents also lengthen the breeding activity due to multiple estrous cycles, which increases the risk of deer-vehicle collisions. Fertility control may have value for use on small isolated populations, but additional research is necessary.

SHARPSHOOTERS

Sharpshooting programs involve the culling of a deer herd by skilled and highly trained professionals. Although more expensive than regulated hunting, sharpshooting is useful in areas where there is land-use conflicts or not sufficient area to support traditional regulated deer hunting programs. Costs can range from $200-450 per deer removed. In addition to reducing the size of the herd, a benefit of sharpshooting is the ability to provide venison to local food banks. LAFB has white-tailed deer sharpshooting operations that are coordinated and executed by the United States Department of Agriculture Wildlife Services (USDA-WS) to shoot deer when there is an immediate threat to flight safety. However, this likely only has a minor impact on deer population control.

REGULATED HUNTING

Regulated traditional hunting programs have proven to be the most efficient and least expensive technique for reducing and maintaining deer populations at acceptable levels. Controlled deer hunts are common on many military and government installations, such as neighboring LAFB. In areas where gun hunting causes safety concerns or intrusive to local human activities, then hunting programs can be restricted to bow hunting.

The presence of white-tailed deer on NASA LaRC property does not appear to be a nuisance issue at this time. However, if deer populations should increase and the animals become a nuisance on the Center, a joint partnership with LAFB is recommended. Excessive populations of the white-tailed deer herd are controlled, in part, by a restricted hunting program on LAFB. The hunting program provides uniformed and retired personnel the opportunity for a sport hunting experience while also contributing to the BASH effort (Langley AFB INRMP 2013).

The introduction of new deer on the NASA LaRC installation is not encouraged because of the size of the installation and the efforts to control deer populations on LAFB. An increase in deer population could result in more deer in public areas leading to an increase in car/deer collisions, the spread of tick-borne disease, and the destruction of vegetation due to the feeding habitats of the deer.

TICKS

Tick control efforts in deer populations have been particularly effective in using the USDA poster deer treatment bait station (Stolberg et al. 2003). Different ticks spread these three common diseases. In Virginia, Blacklegged ticks, also called deer ticks, spread Lyme disease and ehrlichiosis. Lone star ticks and dog ticks spread ehrlichiosis and Rocky Mountain spotted fever. More information on ticks can be found in Section 5.4.3.

5.2.4 MONITORING

LAFB currently has an agreement in place with the USDA Wildlife Services to conduct deer surveys on a regular basis, and LAFB shares these results with LaRC upon request. Tick-borne disease and prevention information should be made available to NASA LaRC staff via a public brochure or poster campaign. NASA LaRC staff should be encouraged to report any incidents of tick-borne disease to SPEEB and the LaRC safety office in order to track any trends on the contraction of such diseases so that the proper control measures can be implemented as deemed necessary.

5.3 WATER QUALITY AND FISH MANAGEMENT

LaRC is located on the small coastal basin of the Back River, a tidal estuary of the Chesapeake Bay. The Brick Kiln Creek runs along the western boundary of LaRC, joining the northwest branch of the Back River, and drains approximately 40% of the Center. Tabbs Creek, which drains most of the rest of the Center and part of LAFB, flows in a northerly direction to join the Back River near the confluence of its northwest and southwest branches. The tidal waters around LaRC serve as important spawning or nursery sites for many commercially and recreationally important species, which in turn supports the regional economy. Fishing is not permitted at LaRC. No fish stocking or direct population management has been undertaken.

The Back River is identified on the state's list of impaired waters due to high levels of Fecal Coliform that impact recreation and shellfish harvesting. A bacteria TMDL (Total Maximum Daily Load) of the Back River and Tributaries was completed in spring 2018. LaRC has a Waste Load Allocation (WLA) for fecal bacteria, with the main source being from wildlife. In addition, the EPA has established the Chesapeake Bay TMDL, which identifies necessary pollution reductions of nitrogen, phosphorus, and sediment across 7 states, including Virginia. Federal facilities in the Chesapeake Bay drainage area, including LaRC, are required to participate in the TMDL process and meet WLA reductions. LaRC submitted Phase 2 of the TMDL Action Plan in May 2018, which demonstrates LaRC's plans for meeting TMDL reduction goals for the next five years and beyond.

LaRC's land mass has 16 drainage basins with 16 associated outfalls (point sources of discharge). The Center operates under four water discharge permits, three from the State and one from the Hampton Roads Sanitation District (HRSD). The HRSD permit allows NASA LaRC to discharge non-hazardous industrial wastewater and sanitary sewage to the HRSD sanitary sewer system. A Virginia Pollutant Discharge Elimination System (VPDES) permit, administered by the DEQ, authorizes NASA LaRC to discharge to surface waters in accordance with the effluent limitations and monitoring requirements set forth in the Permit. LaRC is allowed to discharge effluent from its operations to the surface waters of Virginia at six outfall locations: 001, 012, 009, 003, 008, and 005. The remaining ten outfalls contain only stormwater runoff. Figure 1 shows the locations of the outfalls at NASA LaRC.

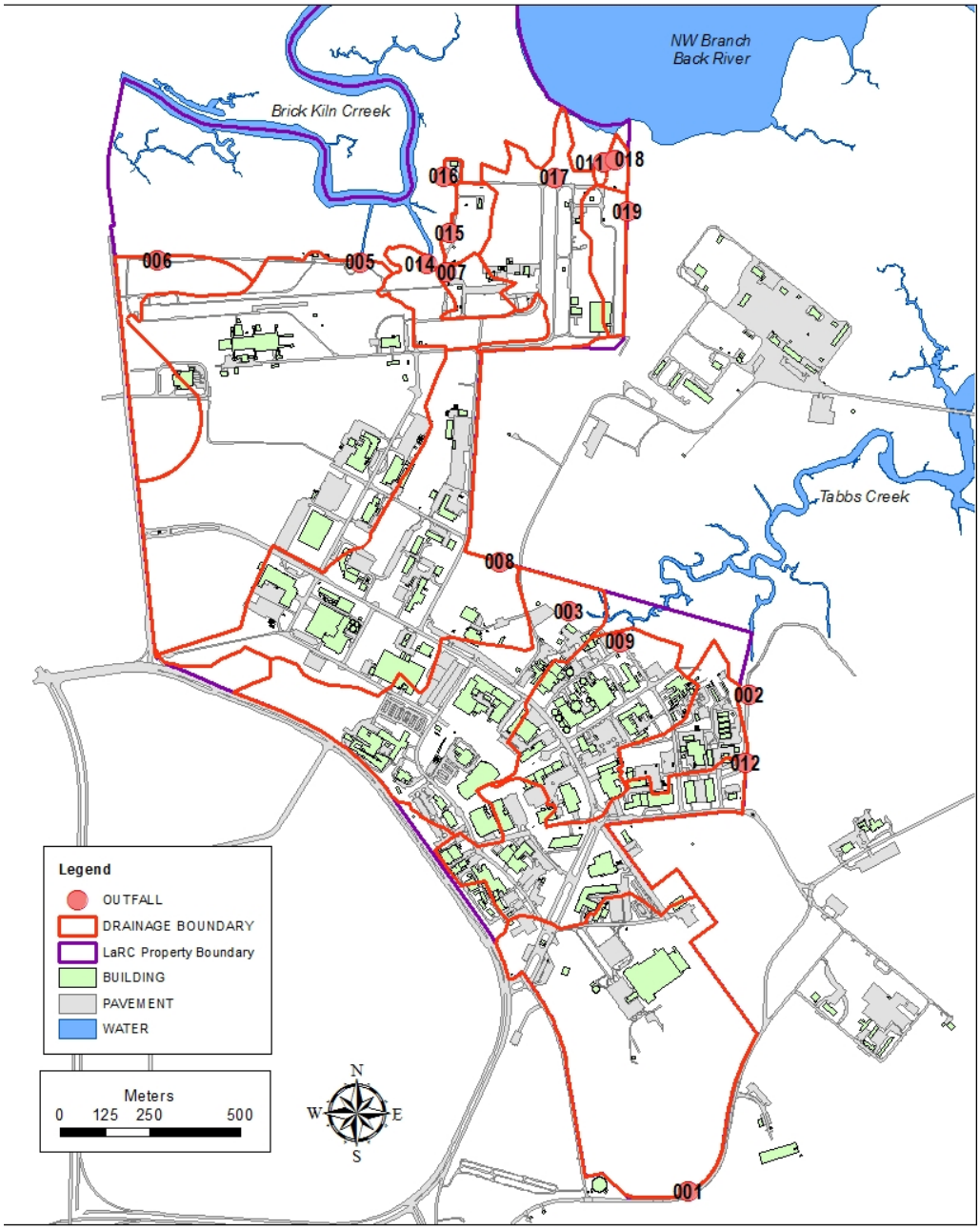

Figure 1 - Location of LaRC's 16 outfalls

Four basic aquatic community types were found to occur at NASA LaRC which includes: brackish tidal marshes, brackish ponds with occasional tidal influence, palustrine freshwater ponds, and brackish and freshwater ditch systems. Tabbs Creek and Brick Kiln Creek are polyhaline tidal creeks comprising intertidal habitats, including mudflats, salt marshes, and shallow subtidal habitats. The diversity of habitats supports numerous aquatic and semi-aquatic species, resulting in high rates of primary and secondary production. Tidal creeks are especially important as nursery areas for larval and juvenile fishes. In addition, numerous species of fish and crustaceans use these systems for foraging and refuge. Many of these species are migratory and use tidal creeks on a seasonal basis. More information on LaRC's aquatic community types can be found in Section 5.2.3 of the ERD.

Thirty-four (34) fish species were collected in the NASA LaRC during the 1995 ODU Survey. All species were common to the lower Chesapeake Bay and its tributaries. Dominant fish species found include hogchoker (*Trinectes maculatus*), oyster toadfish (*Opsanus tau*), silver perch (*Bairdiella chrysoura*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), bay anchovy (*Anchoa mitchilli*), striped killfish (*Fundulus majalis*), rainwater killfish (*Lucanis parva*), and mosquitofish (*Gambusia affinis*). No endangered, threatened, or special concern species inhabit or use the NASA LaRC community. A complete list of aquatic species observed at LaRC can be found in Appendix II.

5.3.1 MANAGEMENT GOALS AND OBJECTIVES

LaRC is located in the ecologically sensitive Chesapeake Bay watershed. LaRC is committed to ensure that Center operations do not negatively affect the water quality of the Bay and its tributaries.

- Maintain compliance with LaRC's four water permits and DEQ-approved Annual Standards and Specifications;
- Conserve and promote conservation of game and nongame fish and their habitats;
- Encourage the growth of oysters in local creeks and rivers;
- Conserve and protect water resources through efficiency, reuse, and stormwater management;
- Ensure that LaRC helps to restore water quality in the Chesapeake Bay; and
- Reduce pollutants of concern (e.g. nutrients, sediment, and bacteria) entering local waterways through compliance with the Chesapeake Bay TMDL and the Back River TMDL.

5.3.2 MISSION AND MANAGEMENT ISSUES

The northern boundary of LaRC (predominantly wetlands), Brick Kiln Creek and the Back River are designated as an Essential Fish Habitat area (https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper). Additionally, the Northwest and Southwest Branches of the Back River are condemned shellfish–growing waters and are identified on the State's list of impaired waters due to high levels of fecal coliform. The following is a list of issues at LaRC related to water quality and fish management:

- Maintaining compliance with the Clean Water Act (CWA);
- Addressing the Back River TMDL for bacteria (fecal);
- Addressing the Chesapeake Bay TMDL for sediment, phosphorous, and nitrogen; and
- Understanding the local fish population and how LaRC affects it.

5.3.3 GUIDELINES AND RECOMMENDATIONS

Stormwater runoff is a major source of water pollution in urban areas. Runoff flowing on impervious surfaces can collect sediment, excess nutrients, bacteria, trash, and other pollutants before entering a waterbody or a storm drain. Excess nutrients in water bodies may cause harmful algal blooms (toxic), increase nuisance plant growth and odors, disrupt species diversity, reduce dissolved oxygen levels, and cause human health impacts. Sediment degrades water quality by binding pollutants, inhibiting

vegetation, clogging ports, channels and storm drains increasing the risks for flooding. High concentrations of bacteria that exceed allowable levels indicate the possible presence of disease-causing bacteria, viruses and protozoa, and often results in beach closures and restrictions on shellfish consumption.

ILLICIT DISCHARGE DETECTION AND ELIMINATION (IDDE) PROGRAM

Illicit discharges are prohibited on Center via Langley Procedural Requirements (LPR) 8500.1, "Environmental and Energy Program Manual." These policies are made available to Center personnel through the Langley Management System (LMS), the public Environmental website, and are also included in annual Environmental Training sessions. LaRC's IDDE Handbook has written procedures to detect, identify, and address unauthorized non-stormwater discharges, including illegal dumping, to the MS4 with the goal of eliminating the unauthorized discharge. This handbook serves as an IDDE program summary and discusses outfall screening, methodologies, inspection protocols, time frames, and source elimination.

GREEN INFRASTRUCTURE AND BEST MANAGEMENT PRACTICES (BMPS)

NASA LaRC implements green infrastructure, a type of Low Impact Development (LID), to treat polluted stormwater runoff before it is discharged to local waterways. Green infrastructure works by slowing down the runoff, spreading it out over the land, and slowly soaking it into the ground. These techniques also help to remove pollutants from runoff by allowing plants to filter out pollutants as the water slowly infiltrates into the ground. Green infrastructure implemented at LaRC include vegetated roofs, multiple bioretention and rain gardens, grass channels, pervious pavers, and tree box filters.

Various BMPs are implemented to prevent or mitigate stormwater and/or sewer system pollution from facility activities. These include employee training, preventive maintenance, visual inspections, spill prevention and response, sediment and erosion control, good housekeeping, and record keeping and reporting. BMPs are also employed in the Center's pesticide and herbicide program. Land-disturbing and construction activities are carried out in compliance with appropriate State requirements (Permit VAR10) and, historically, have not caused any increased sediment discharge into receiving waters. LaRC will continue to minimize these pollutant streams through permitting, inspections, and the use of best management practices.

POLLUTION PREVENTION (P2) PROGRAM/GOOD HOUSEKEEPING

Over the last several years, LaRC has built a quality stormwater pollution prevention (P2) program that uses a variety of operational and maintenance BMPs to ensure that Center operations are accomplished in a way that minimizes or prevents pollutant discharges. Street sweeping and catch basin maintenance is LaRC's preferred method to prevent stormwater pollution, as it is aimed at collecting debris and floatables prior to their being washed into the MS4 and discharged into local waterways. Debris collected by these practices include sediment, litter, metals, petroleum products, organics, and other pollutants. LaRC will continue to maintain a street sweeping and catch basin maintenance schedule at least quarterly. It is also beneficial to utilize street sweepers to remove debris after events that result in heavy pollutants in the roadway, such as after winter storms (sand and salt), after heavy storms, around large construction projects, and after an accidental petroleum spill.

RIPARIAN BUFFERS

Riparian buffers are the natural vegetation from the edge of the steam or creek bank out through the riparian zone and provide a transition between aquatic and terrestrial ecosystems. These areas serve as a natural buffer to pollutants entering the local water body from runoff, control erosion, and provide valuable habitat for local wildlife. Additionally, riparian buffers also provide protection during storms and storm surge. NASA Langley has reforested many areas in the North 40 with a mix of native hardwoods and pines. Many of these trees are strategically planted in areas around LaRC's nearby waterways. These projects are an inexpensive way for LaRC to earn "credits" toward pollution reduction goals for the Chesapeake Bay TMDL.

5.3.4 MONITORING

NASA LaRC strictly adheres to applicable State and local erosion and sediment control/stormwater management laws and regulations to ensure minimal impact to water quality. LaRC should continue to maintain a robust GIS-based MS4 map that includes a storm sewer map and information table as well as enforce the IDDE Program by continuing to provide training to staff and resources for effective reporting.

NASA Langley contracts the street sweeping and catch basin operations through the grounds maintenance contractor. Currently, sweeping activities are completed quarterly and the weight tickets of debris collected are submitted to SPEEB. It is recommended that SPEEB continues to receive and monitor these reports to track total sediment removal on Center.

Areas that have been reforested should be monitored at least annually for health status, vegetation loss, damage from wildlife, and lessons learned for future reforestation activities. Additional reforestation efforts and conversion of mowed grass area to a natural riparian buffer should be planned in the future in order to maximize groundwater absorption, improve water quality, and expand forested habitats.

5.4 NUISANCE WILDLIFE MANAGEMENT

Nuisance wildlife is wildlife that, because of their feeding or nesting habits, interferes with the Center mission or well-being of other wildlife, or humans. The most common nuisance animals currently at NASA LaRC include feral cats, squirrels, raccoons, and foxes. Canada geese and deer are present on the installation and have the potential to become a nuisance. Also, there has been an increase of coyotes with several reported incidents in Hampton and Poquoson. These predators can be involved in the spread of tick-borne diseases, rabies, and parasites. These animals are considered nuisance pests when inside and around buildings (or other structures/facilities) and may require periodic removal in accordance with applicable regulations.

Nutria, an invasive rodent that feeds heavily on vegetation in wetlands and marshes, has been documented in southern Hampton Roads. While not yet present at LaRC, it is important to monitor the wetland and marsh areas and report any sightings to the VDGIF.

5.4.1 MANAGEMENT GOALS AND OBJECTIVES

Establish coordinated management of feral and nuisance animals at LaRC to protect human health and safety, increase biodiversity, reduce impacts (potential or real) on migratory birds and small mammal populations, and protect property.

5.4.2 MISSION AND MANAGEMENT ISSUES

The following is a list of the most pressing nuisance wildlife-related management issues:

- Wildlife that is nesting in and near buildings (this is especially true for raccoons);
- Wildlife feeding by humans, especially foxes;
- Wildlife deterrence from the centralized-campus area;
- Mosquito control;
- Canada geese and deer population management if they become a nuisance; and
- Fecal bacteria load reductions for compliance with local TMDLs.

5.4.3 GUIDELINES AND RECOMMENDATIONS

NUISANCE WILDLIFE

Building occupants/users should contact SPEEB if nuisance wildlife exists in these areas. All nuisance wildlife incidents (whether real or perceived) shall be coordinated with SPEEB to avoid potential violations of state and/or federal laws as well as appropriate disposition of the animal regarding disease issues or wildlife management. It is a violation of certain federal and state laws to feed wildlife. SPEEB should continue to provide public outreach about wildlife and monitor areas where there is evidence of feeding these animals.

The VDGIF suggests some easy techniques which may solve the problem of nuisance and problematic wildlife and prevent them from re-occurring (https://www.dgif.virginia.gov/wildlife/nuisance/):

- Feeding wildlife on Center is prohibited; feeding wildlife causes them to lose their natural fear of humans;
- Keep trash inside until the morning of trash pick-up or place trash in an animal-proof container, such as a metal trashcan with latches on the lids;
- Remove bird feeders when problem species, such as raccoons, have been seen around them;
- Close up all openings under and into the buildings. Animals look for places to den and raise their young—don't give them that opportunity;
- Clear overhanging tree limbs and branches which may be providing wildlife access to structures;
- Clear fallen fruit from around trees around buildings;
- Mothballs placed in trash cans or around buildings will repel some species; and
- Reflective tape, lights, or noise sometimes works, but they will eventually grow accustomed to these methods, so this is only a temporary solution.

It is illegal in the State of Virginia to trap and relocate an animal to another area. If the above techniques do not solve the problem, SPEEB shall coordinate with the USDA-WS for removal, and

if necessary obtain appropriate permits for nonnative and nuisance plant species eradication in wetland areas.

In 2000, LAFB contracted with the USDA-WS to initiate a formal and aggressive BASH program. The BASH Plan outlines management and control measures for both flora and fauna within the flight line area to minimize impacts to aircraft. NASA LaRC currently utilizes the services of the USDA-WS and these management concepts can be incorporated at NASA LaRC as appropriate.

MOSQUITO CONTROL

Mosquito-borne diseases found in Virginia include:

- West Nile virus
- Eastern equine encephalitis
- La Crosse encephalitis
- St. Louis encephalitis

To prevent the formation of free-standing water, properly designed and maintained modern best management practices (BMPs) and low impact development (LID) techniques can treat stormwater and alleviate concerns about vectors. This action would also discourage the formation of mosquito breeding habitat. Several control measures can be utilized including natural drainage of breeding sites, removal of tire piles and other man-made breeding sites, larviciding using Altosid and BTI, construction of natural habitats to promote bats and purple martin, adulticiding using Dibrom® aerially, and Anvil® in a ground fogger. More information is located in Appendix I.

CANADA GOOSE MANAGEMENT

The resident Canada goose population has grown significantly throughout Virginia and much of the United States during the past several decades and Canada geese are now considered a nuisance in many places. Resident Canada geese are those that nest within the region in the months of March, April, May, or June, or that reside within the region in the months of April, May, June, July, and August (USFWS 2007).

If large populations of Canada geese become established at NASA LaRC, they can damage grass areas through overgrazing, trampling, and through their excrement. Large amounts of fecal droppings around the facility create unsanitary work conditions, increase the transmission of fecal coliform bacteria, and create excess nutrients in the surrounding water resources, which can lead to water quality problems. Additionally, LaRC was given a waste load allocation for fecal bacteria for the Back River TMDL. Much of this fecal bacteria may come from nuisance Canada geese on the Center. An increase in resident geese population also poses a threat to the numerous aircraft missions occurring daily at the Center. The damage caused by these geese will continue to increase if no action is taken to prevent their occurrence.

In 2006, the USFWS revised regulations that pertain to resident Canada geese (71 FR 27 45964). The regulation allows landowners to remove Canada geese at airports, in agricultural areas, and in other

areas where they are causing conflicts with human populations. The Nest and Egg Depredation Order is an additional tool that will allow landowners to destroy resident Canada goose nests and eggs when necessary to resolve or prevent injury to people, property, agricultural crops, or other interests. Under this order, no permit is required, but the landowner must register with the USFWS in order to conduct this activity. The landowner or land manager (including employees that may conduct the work) must register each year prior to taking nests and eggs. Nests and eggs may be taken only between March 1 and June 30. Procedures approved by the Humane Society of the United States (2004) for egg addling should be used.

NASA Wallops Flight Facility (NASA WFF) has developed a management plan for resident Canada geese on the Main Base. This long-term removal program aims at keeping the population of these birds as close to zero as possible. A similar plan could be adopted by NASA LaRC. The plan employs such methods as (1) conducting roundups when the birds are flightless during summer molt; (2) capture through the use of the immobilization drug alpha chloralose; (3) capture using decoy traps or other large cage traps; and (4) removal by means of shooting. Canada geese that are live-captured with roundups or traps are taken to a processor and the meat is donated to feed the needy or donated to a zoo. Geese captured live using alpha chloralose are euthanized and buried since federal regulations state the birds would have to be held for 30 days before they could be processed and donated for consumption. The program is conducted between the months of March and August when there is no risk of migratory Canada geese being present. Conducting an early season program that targets resident Canada geese would be the most effective means of population reduction. More information is located in Appendix I.

TICK CONTROL

Tick-borne diseases found in Virginia include:

- Anaplasmosis and Ehrlichiosis
- Babesiosis
- Lyme disease
- Rocky Mountain spotted fever

Additionally, the Lone Star tick is found in Virginia and is known to cause an alpha-gal meat allergy.

Preventive measures should be taken that can greatly reduce the risks of contracting tick-borne diseases. Simple avoidance of areas where ticks are likely to be found may be effective, but not always practical. If activities must be undertaken where tick exposure is likely, light-colored clothing should be worn to allow ticks to be easily seen and pant legs should be tucked inside of socks. Repellents, such as those containing DEET or permethrin, should be used to discourage ticks. (NOTE: DEET should be used with caution when applied to children and permethrin may only be applied to clothing, not directly to skin). Additionally, thorough body checks should be conducted after at-risk activities. More information can be found in Appendix I.

Adherence to these precautions may not prevent all tick bites; however, prompt removal of ticks will reduce the risk of disease transmission. Additional studies aimed at reducing tick populations are recommended.

5.4.4 MONITORING

Nuisance wildlife issues and mosquito-borne disease prevention information should be made available to NASA LaRC personnel via a public brochure or poster campaign. NASA LaRC personnel should be encouraged to report any incidents of nuisance wildlife near buildings or the contraction of any mosquito-borne disease to SPEEB and the NASA LaRC Safety Office in order to track any trends of wildlife sightings or contraction of mosquito-borne diseases so that the proper control measures can be implemented as deemed necessary.

5.5 THREATENED, ENDANGERED AND SPECIES OF CONCERN MANAGEMENT

The most current biological surveys of NASA LaRC include the facility-wide habitat classification and species survey in 2009 by Science Applications International Corporation (SAIC) and the facility-wide fish, wildlife, and plant surveys by ODU conducted in 1995. Due to the spatial setting of the NASA LaRC facility, it is not considered likely that threatened or endangered species occur on a regular basis. Although small species such as birds or small mammals could take up residence in the wooded areas within the facility, the habitat is not ideal for most species because the Center is relatively small, largely developed, and surrounded mostly by developed area. The wildlife observed during the 2009 SAIC survey was dominated by "backyard" species that are common in suburban environments. The only exception to this characterization were the two larger game species observed (whitetail deer and wild turkey), which likely have taken up residence and/or established populations because the facility has restricted access and therefore provides protection from predation and hunting.

Seven species of reptiles and amphibians were identified at NASA LaRC by SAIC in the 2009 survey and sixteen species were identified during the ODU survey. No special status species were encountered during the surveys. However, species like the canebrake rattlesnake (*Crotalus horridus* formerly *C. horridus actricaudatus*), Eastern glass lizard (*Ophisaurus ventralis*) and various species of sea turtles (*Caretta, Lepidochelys, Chelonia*, etc.) can be found in the greater Hampton Roads area.

Three mammalian species were encountered at NASA LaRC during the 2009 survey by SAIC and fourteen species of mammals were identified during the ODU survey. Based on historical distribution data, twelve additional species could inhabit the area but were not observed during the study. None of the mammals are currently listed as threatened, endangered, or species of concern.

A total of 25 avian species were observed at NASA LaRC during the SAIC survey in 2009 and none are federally or state listed as threatened, endangered, or species of concern. During the 1995 survey by ODU, 118 species of birds were observed. None are federally listed as threatened, endangered, or

species of concern. Twelve (12) species observed at NASA LaRC during the ODU (1995) and/or the SAIC (2009) surveys are currently state-listed threatened or BCC species: Bald eagle (*Haliaeetus leucocephalus*), Pied-billed Grebe (*Podilymbus podiceps*), snowy egret (*Leucophoxy thula*), solitary sandpiper (*Tringa solitaria*), lesser yellowlegs (*Totanus flavipes*), least tern (*Sterna albifrons*), gull-billed tern (*Sterna nilotica*), wood thrush (*Hylocichla mustelina*), blue-winged Warbler (*Vermivora pinus*), prairie Warbler (*Dendroica discolor*), worm-eating Warbler (*Helmitheros vermivorus*), and Henslow's Sparrow (*Ammodramus henslowii*). Although not sited during the ODU survey of NASA LaRC, the peregrine falcon (*Falco peregrinus*), another State-listed threatened species, was sited at adjoining LAFB during a survey of the base in 1994 (Geo-Marine, 1994). The gull-billed tern, and the Henslow's sparrow were determined to be transient migrants who use the NASA LaRC facility solely as a foraging stop. A complete list of bird species observed at LaRC can be found in Appendix II.

Thirty-three finfish species were collected at NASA LaRC during the ODU study. All species were common to the lower Chesapeake Bay and its tributaries. No endangered, threatened, or special concern species inhabit or use the NASA LaRC community.

It is most likely that threatened or endangered species occurring on the Center would be limited to seasonally present or transient bird species. No plants, reptiles, amphibians, mammals, birds, or fish species federally listed as threatened or endangered were found in any of the habitat types at NASA LaRC.

5.5.1 MANAGEMENT GOALS AND OBJECTIVES

The overall goal is to ensure compliance with the Endangered Species Act and applicable state regulations and to protect and enhance rare, threatened and endangered species (RT+E) and their habitats. Specific goals include the following:

- Assess and monitor the occurrence of RT+E species at LaRC
- Avoid impacts to RT+E species and their habitat (currently may be only transient occurrences); and
- Where feasible, introduce RT+E populations when no mission impact is anticipated.

5.5.2 MISSION AND MANAGEMENT ISSUES

No mission or management issues identified.

5.5.3 GUIDELINES AND RECOMMENDATIONS

No protected species were observed during the surveys and NASA LaRC does not offer habitat that is likely to host threatened and endangered species on a regular basis. Therefore, no specific habitats are recommended for protection at this time. If a threatened and/or endangered species is identified or critical habitat is established on NASA LaRC property, consultation with the USFWS would be necessary to develop the proper management plans, and species information and management actions would be incorporated into the INRMP.

As feasible, LaRC will attempt to restrict tree removal and ground clearing activities, and adhere to a time-of-year restriction from March 15 through August 15 of any year to protect nesting resident and migratory songbirds.

5.5.4 MONITORING

Continue to conduct biological surveys of the installation of terrestrial and aquatic habitats with a special emphasis on threatened and endangered species, such as the biological survey conducted by Old Dominion University (ODU) in 1995. An update of these surveys every 5-10 years can provide a more accurate picture as to the habitats and species present within the installation boundaries. This information should be used to guide any natural resource projects in order to protect any RT+E habitat or known species.

Around December and again in the spring, the Center should implement a bird counting effort by NASA LaRC staff and/or local bird watching clubs. The "Christmas Bird Count" and the "Spring Bird Count" promote bird watching and appreciation and provides bird watchers the opportunity to hone their skills.

5.6 HABITAT MANAGEMENT

In 2009, the SAIC conducted a facility-wide land habitat classification and species identification survey at LaRC. Fourteen habitat types were documented at the Center during the survey (see Figure 2). The dominant habitat types consist of Developed and Maintained areas. Developed areas include man-made structures consisting of buildings, roads, sidewalks, parking lots, industrial equipment and various infrastructure facilities. Maintained Areas dominate LaRC's flora and include all vegetated urban areas consisting of grasses, shrubs and ornamental vegetation that are routinely maintained. Other areas that exist in an unnatural state include Disturbed Areas and Drainage Areas. Disturbed Areas may consist of bare ground that has been graded or otherwise cleared with limited ability to support vegetation or other cover; vegetation, if present, is widely spaced and scrubby. Drainage Areas consist of linear water passages where the water course is interrupted by controlled structures such as culverts. The rest of the Center consists of Coastal Plain Forest, of which there are seven habitat sub-categories, and is dominated by hardwood, with evergreens being predominant in the southern forested area.

Forest edges are typically dominated by old field/roadside vegetation. This type of habitat of NASA LaRC represents an ecologically important habitat type. It exists wherever woodland or forest gives way to open fields. One large open field area with significant habitat value is located in the northern part of the facility. The frequency of mowing here is sufficient to discourage the succession of woody vegetation, and maintains the area in a perpetual early old-field successional stage, dominated by perennial grasses and forbs. Old-field habitats such as this provide nesting habitat for a number of ground-nesting bird species, and foraging habitat for numerous bird and small mammal species. Since 2009, LaRC has reforested over 3.5 acres with a mix of native hardwoods and pines. Many of these trees are strategically planted in areas around LaRC's nearby waterways and act as riparian buffers

to protect local waterways and provide valuable habitat. Furthermore, these projects are an inexpensive way for LaRC to earn "credits" toward pollution reduction goals for the Chesapeake Bay TMDL. Additional reforestation efforts are planned in the future in order to maximize groundwater absorption, improve water quality, and expand forested habitats.

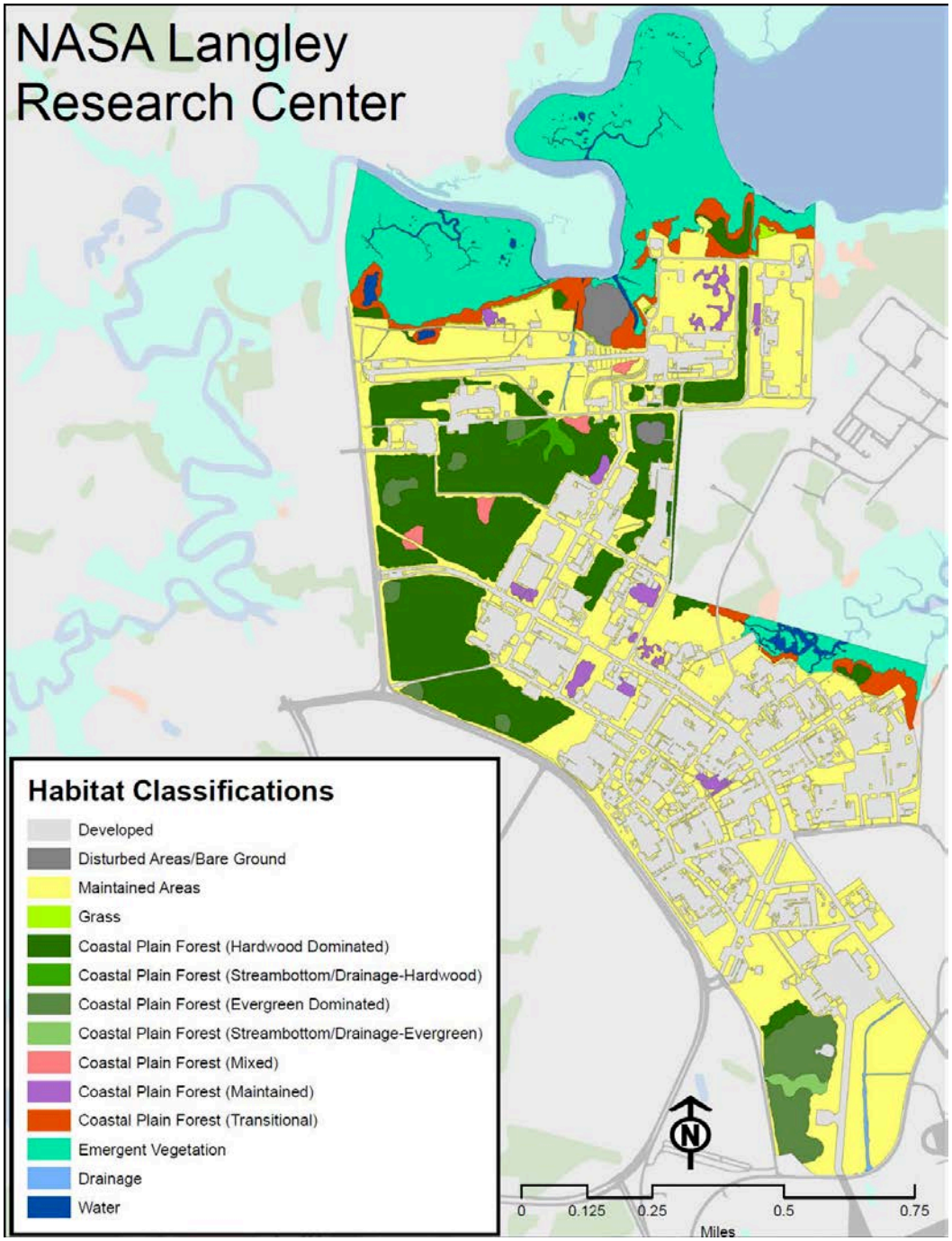

Figure 2 - Habitat Classifications at NASA LaRC

5.6.1 MANAGEMENT GOALS AND OBJECTIVES

The overall goal is to conserve, restore, and enhance the biological diversity and ecological integrity of plants and wildlife in the various habitats found at LaRC. Specific goals include:

- Identify, protect and enhance key habitats needed by wildlife to maintain a healthy ecosystem;
- Assess adverse and beneficial environmental impacts associated with projects; and
- Mitigate adverse impacts to the greatest extent practicable to minimize the effects on natural resources.

5.6.2 MISSION AND MANAGEMENT ISSUES

The following is a list of the most pressing habitat-related management issues:

- There are several locations on the Center where the ground cover has been degraded by demolition and other activities (heavy presence of rocks in soil, poor topsoil quality, etc.); and
- When buildings are demolished, there is competition for space by various organizations. However, these areas could be converted to valuable green space.

5.6.3 GUIDELINES AND RECOMMENDATIONS

The following methods are recommended in order to conserve, restore, and enhance habitats at LaRC:

- Native plants reduce time and cost for plant establishment, contribute greatly to healthy soil and water, are important for biodiversity, and provide food and shelter for native animals. Installing native plants, when feasible, should be the preferred method at LaRC.
- Restoring the vegetation at demolition sites will not only reduce erosion, but will enhance the native plant and wildlife habitat values in the immediate area, improve diversity, and restore conditions suitable for outdoor recreation.
- Quality and diversity of early successional habitat, including grasslands, can be achieved through clear-cutting and maintaining areas already in early successional stages. Many tools such as prescribed fire and fertilization of native vegetation can be used to maintain these areas.
- Maintaining edge habitat is one means of enhancing biological and structural diversity at LaRC. Edge occurs wherever two different plant communities or successional stages meet. Wildlife species richness in edges is typically higher than in surrounding areas as a result of the increased plant and habitat diversity. Many bird species are attracted to edge habitats because of the greater structural diversity found there; preference for edge habitat by game species is due to the close association of cover and foraging areas.
- Fescue fields are not considered part of the early successional habitat for wildlife. Fescue eradication and subsequent planting of native wildflowers and forbs in these areas would benefit wildlife on NASA LaRC.
- Dead and dying trees (called snags) and live trees with natural cavities are important habitat components for many wildlife species. Snags and cavity trees provide foraging, nesting,

roosting, and perching sites. The abundance of woodpeckers, raptors, passerines, small mammals, and bats in an area are often directly related to the availability of snags and tree cavities. Tree snags, that do not impact personal safety and the protection of facilities, should be retained for wildlife values.

- Artificial cavities or nest boxes should be used at LaRC in areas where snags are limited or nonexistent. Nest boxes provide habitat for cavity-nesting animals and can be used to encourage the use of a habitat by one or more species. Some species of birds and mammals (e.g., wood duck, gray squirrel) actually use nest boxes more frequently than natural cavities when boxes are available (McComb and Noble 1981). More information can be found in Appendix I.
- Prescribed fire is a management tool that has a variety of applications in natural resources management. Most commonly, prescribed fire is used to maintain early successional habitat, improve wildlife habitat, and control undesirable vegetation. Installation and maintenance of firebreaks around each burn unit to protect adjacent land and fire lines within each burn unit to facilitate access are vital to safe and successful controlled burning. Firebreak construction must comply with applicable federal, state, and local laws and regulations, including the state's Best Management Practices (BMPs) which can be viewed at the Virginia Department of Forestry's website. Prescribed burning should only be conducted by trained and experienced personnel. Proper diagnosis of fire conditions and detailed planning are needed each time a burn is conducted. The impact on all resources should be considered, including wildlife, protected species and habitats, forest cover type, riparian areas, air quality, and aesthetics. Burning in early spring before birds arrive (prior to April 15th) is most beneficial to vegetation and nesting birds. Although some ground-nesting birds will not nest immediately following a burn, they will increase one or two years after a burn. Existing shrubby or grassy and weedy edges, particularly along wetlands and streams should be maintained as they serve to protect soils, control erosion, improve water quality, and provide for wildlife habitat.
- Reforested areas act as riparian buffers to protect local waterways and provide valuable habitat. Forests also reduce soil erosion, improve water quality, reduce runoff, and recharge groundwater. LaRC should continue to evaluate areas that can be converted from mowed green space to no-mow reforested areas.
- Reforestation projects should follow the Chesapeake Bay TMDL Guidance Document Table V.F.2, which recommends a minimum of 400 seedlings per acre to reclassify a land use change as forest land. LaRC should work with the Virginia Department of Forestry when evaluating tree costs and species, and ideal planting techniques for scope of work development. All bare-root seedlings should be protected with a solar tree tube to shelter the seedling during early growth. Additionally, the tree tube should have bird exclusion netting across the top of the tube to prevent birds from being trapped within the tubes.
- LaRC should continue to implement a tree replacement strategy for trees removed during construction or demolition projects. For each tree removed, a combination of trees totaling the diameter at breast height (DBH) of the tree removed shall be planted. Location of the

replacement trees shall be coordinated with SPEEB. Replacement trees should be warrantied for a period of one year.

5.6.4 MONITORING

Existing land cover and habitat types are mapped at NASA LaRC by geographic information system (GIS) staff. Annual surveys of habitat type should be conducted to revise the land cover and habitat type GIS layer. Conversion of habitats can be measured over time using GIS.

5.7 DEMOLITION AREA MANAGEMENT

As part of the ViTAL Program, numerous facility and structural demolitions are occurring throughout the Center and will continue over the next decade. In total, over 100 structures are planned to be demolished. The demolition of non-essential assets, such as abandoned or underutilized facilities, will result in reducing LaRC's footprint and establishing a centralized core campus featuring state-of-the-art, energy efficient facilities.

5.7.1 MANAGEMENT GOALS AND OBJECTIVES

LaRC has the following management goals and objectives for demolition area management:

- Return areas to green space by removing all surface infrastructures to include building foundations and associated paving around the facility/structure;
- Divert as much demolition materials as possible from landfills; and
- Re-plant with native vegetation.

5.7.2 MISSION AND MANAGEMENT ISSUES

The following is a bulleted list of the most pressing demolition area management issues:

- Demolition of buildings without removal of associated impervious surfaces (e.g., parking lots, sidewalks, equipment pads, cement); and
- Typically, a demolished area is planted with a basic fescue-type grass cover. Converting areas into buffers, wind breaks, wildflower fields, etc. is not usually planned, discussed, or budgeted for.

5.7.3 GUIDELINES AND RECOMMENDATIONS

LaRC has incorporated Annual Standards and Specifications for Erosion and Sediment Control (ESC) and Stormwater Management (SWM). This document, administered by SPEEB, outlines the requirements for ESC and SWM for construction and demolition activities on Center. SPEEB evaluates projects and any potential environmental impacts based on these standards and specifications, and through the LF 461, Environmental Project Planning web-based system. Any land disturbing activity shall adhere to ESC practices to minimize water quality impacts.

Restoring the vegetation at demolition sites will not only reduce erosion, but will enhance the native plant and wildlife habitat values in the immediate area, improve diversity, and restore conditions

suitable for outdoor recreation.

What to plant: Native grasses are recommended when possible to provide habitat for a diversity of wildlife. Grass species should be determined based on the following criteria: the amount of rainfall, length of growing season, temperature extremes, and soil conditions such as pH, water-holding capacity, aspect, fertility, drainage, salinity, and alkalinity. Soil maps, available from local Natural Resource Conservation Service (NRCS) offices, will help determine what types of native grasses are most suitable for the planting area. Appropriate plant materials and important considerations are available in the Virginia Erosion and Sediment Control Handbook Chapter 3.32 (Permanent seeding).

Prior to planting, provide a firm, weed-free seedbed and uniform soil moisture to ensure that plants will not dry. Follow seeding specifications, such as planting depths, soil types, seeding rates, and fertilizer needs, set by the seed supplier. Planting a mixture of grasses provides greater diversity for wildlife habitat. However, be sure grass species are compatible in the rate of establishment, maturity, and growth habits to ensure the survival of all species planted and to create a uniform stand.

Restored areas of less than five acres that are not adjacent to other fields or open habitats may benefit from wildflowers and butterflies, but such parcels will not likely be used by grassland birds.

Creation of Stormwater Management Bioretention Ponds: When a new construction project requires the creation of a stormwater management facility, it is recommended that the use of bioretention areas are evaluated. Bioretention ponds or urban bioretention boxes improve water quality, reduce water quantity at runoff, and can incorporate the use of native vegetation. Demolition areas should be used for the bioretention area, rather than forested or vegetated areas.

5.7.4 MONITORING

Similar to land cover and habitat types, continue to utilize GIS to track the conversion of demolition areas to natural habitats or stormwater facilities.

5.8 WETLANDS MANAGEMENT

NASA LaRC is located in an area of low topographic relief surrounded by a shallow estuarine environment. The Center is close to the northwest and southwest branches of the Back River, and is within the tidal zone of the Chesapeake Bay. The principal drainage ways in the vicinity of the Center, Brick Kiln Creek and Tabbs Creek are tidal creeks with extensive tidal marshes.

In 1991 Old Dominion University (ODU) performed a wetland field survey at NASA LaRC to identify and map the boundaries of forested wetlands. The predominant wetland areas identified were the tidal marsh wetlands associated with Brick Kiln Creek and Tabbs Creek. These wetland areas were identified as an estuarine emergent marsh dominated by nearly uniform stands of saltmarsh cordgrass (*Spartina alternaflora*) in the lower intertidal zone, and saltmarsh hay (*S. patens*) and salt

grass (*Distichlis spicata*) in the high intertidal zone. Additional dominants in the high marsh were groundsel tree (*Baccharus halmifolia*), rush (*Juncus spp.),* big cordgrass (*S. cynosuroides*) and marsh elder (*Iva fructens*). Common reed (*Phragmites australis*) was common around the upper fringes of the marshes and in areas that have been disturbed by materials such as fill and riprap.
The ODU survey identified three types of forested wetlands at the Center: red maple (*Acer rubrum*) swamp dominated by red maple with some sweetgum; sweetgum (*Liquidambar styraciflua*) swamp dominated by sweetgum, with black gum (*Nyssa sylvatica*) and willow oak (*Q. phellos)*; and water oak (*Quercus nigra*) pond wetlands dominated by water oak and laurel oak (*Q. laurifolia*). These wetlands were identified primarily along the upper reaches of the Brick Kiln Creek and Tabbs Creek marsh wetlands, and in the undeveloped portion of the LaRC West Area. The survey determined that the forested wetlands may be remnants of a larger wetland area that had been converted to nonwetland by ditches and draining. Shrub-scrub wetlands were identified in limited areas, mostly in ditches adjacent to the marsh wetlands. Young red maple, sweetgum, and willow (Salix sp.) characterize the shrub-scrub wetlands. Figure 3 identifies the location of LaRC's wetlands according to the most current National Wetlands Inventory (NWI). According to the NWI, approximately 66 hectares (163.2 acres) total of scrub shrub, emergent and forested wetlands are present in LaRC.

NASA Langley has two facilities located within the wetland areas: a tidal gauge pier (installed in 2015), and the Construction Debris Landfill (CDL) (a long-term monitored Comprehensive Environmental Response, Compensation, and Liability Act site). These facilities are in restricted areas and not actively visited by LaRC personnel. LaRC's 20-year revitalization plan has focused heavily on moving away from flood-prone areas and building new construction in the central area of the Center.

Water resources are protected on NASA LaRC through recognition of special natural areas, application of buffer zones around significant resources, and implementation of regional management goals and objectives as required by the CWA, Coastal Zone Management (CZM) Program, EO 11990 "Protection of Wetlands", EO 12088 "Pollution Control Standards", and Virginia Wetlands Act. Although Federal lands are excluded from Virginia's Coastal Management Area, any activity on Federal land that has reasonably foreseeable coastal effects must be consistent with the enforceable policies of the CZM Program. Federal compliance with EO 12088 and the CWA require federal facilities to comply with all substantive and procedural requirements applicable to point and nonpoint sources of pollution. In accordance with these requirements, NASA LaRC must obtain all appropriate federal, state, interstate, and local certifications and permits required by point and nonpoint pollution control, groundwater protection, dredge and fill operations, and stormwater management programs for any action that may impact water quality.

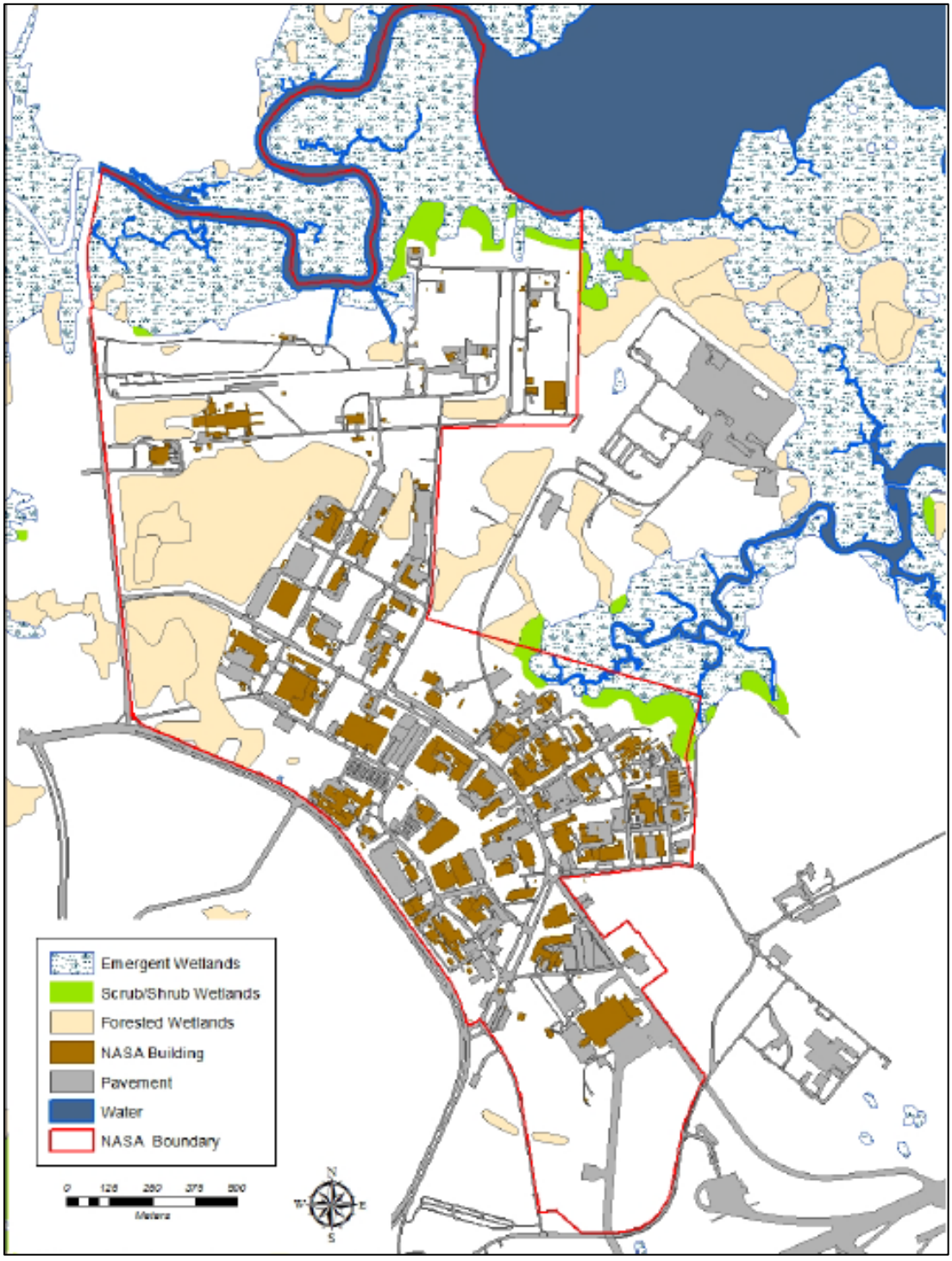

Figure 3- NASA LaRC Wetlands

5.8.1 MANAGEMENT GOALS AND OBJECTIVES

The overall goal is to comply with federal, state, local and NASA regulations on wetlands management and protection. Specific goals include the following:

- Avoid and minimize impacts to undisturbed forest, wetlands, and streams to the fullest extent practicable;
- Maintain undisturbed naturally vegetated buffers of at least 100 feet in width around all on-site wetlands and on both sites of all perennial and intermittent streams;
- Mitigate any unavoidable impacts in accordance with federal, state, local and NASA regulations;
- Enhance wetland habitats where feasible; and
- Enhance riparian buffers where feasible, particularly in areas where demolition has occurred or where non-permeable surfaces can be removed with no impact to mission.

5.8.2 MISSION AND MANAGEMENT ISSUES

Mission and management issues for wetlands include the following:

- Old wetland delineation; and
- Projects (such as installation of Security Cameras/poles w/foundations) impacting wetlands.

5.8.3 GUIDELINES AND RECOMMENDATIONS

The City of Hampton does not have jurisdiction over federal property and the CBPA requirements do not apply to NASA LaRC; however, the Center has set its own policy to avoid land use in areas analogous to Resource Protection Areas (RPAs) and Resource Management Areas (RMAs). It is recommended that NASA LaRC obtain a full wetland delineation of the entire property either by the USACE or by a local consulting firm to accurately identify the location of any wetlands on the property. This would allow for proper planning to avoid impacts to any federal and/or state jurisdictional waters, including wetlands, on the property or allow for planning that would minimize impacts to these jurisdictional areas to the maximum extent practicable.

The VDEQ requires permits under the Virginia Water Protection (VWP) Permit Program (Virginia Administrative Code 25-210) for any impacts to state waters and wetlands, including isolated wetlands. The Joint Permit Application (JPA) is used to apply for permits (i.e. standard/ permits or general permits) from the Norfolk District US Army Corps of Engineers (USACE) for work in the waters of the United States (including wetlands) within Virginia. The JPA process and JPA forms are used by the USACE, the Virginia Marine Resources Commission (VMRC), the VDEQ, and the City of Hampton Wetlands Board for permitting purposes involving tidal and/or non-tidal water, tidal and/or non-tidal wetlands, and/or dune/beach resources, including, but not limited to, construction, dredging, filling, or excavation. Permits are requested by submitting a JPA coordinated through SPEEB to the VMRC. This application process will result in either an individual or general permit issued by the USACE and separate permits by the state and local agencies, as appropriate, or denial of the permit(s).

If permits are issued that encompass loss of wetlands, NASA LaRC should strive to achieve a goal of no net loss of values and functions of existing wetlands and also take a progressive approach toward protecting existing wetlands and rehabilitating degraded wetlands. Although permits may be obtained

that allow for the filling of wetlands, in accordance with EO 11990, federal agencies may do so only after finding no practicable alternative. NASA LaRC policy should be to first avoid impacts to wetlands/aquatic resources where practical. In situations where avoidance is not possible, means to minimize the impacts will be considered. When avoidance and minimization are not possible, mitigation in the form of compensatory mitigation must be met. This may require the creation of in-kind wetlands at other locations on the facility, purchase of wetland mitigation bank credits or a payment into the Virginia Aquatic Resources Trust Fund. Projects that potentially or are known to impact wetlands may require an environmental impact assessment in accordance with NEPA regulations. Information on individual and state permit requirements and application procedures (including JPAs) is available on the Norfolk District website at http://www.nao.usace.army.mil/Missions/Regulatory.aspx.

Additionally, LaRC should evaluate stormwater ditches for areas that would benefit being transformed into natural wetland habitat. To accomplish this, these ditches could be transitioned into a no-mow status to allow the natural growth of wetland plants. This effort would also result in cost savings for the grounds maintenance contract.

5.8.4 MONITORING

Continue to conduct biological surveys of the installation of terrestrial and aquatic habitats such as the biological survey conducted by ODU in 1995. An update of these surveys every 5-10 years can provide a more accurate picture as to the habitats and species present within the installation boundaries. This information should be used to guide any natural resource projects in order to protect existing habitats, plant and animal populations.

5.9 RIPARIAN BUFFER MANAGEMENT

As discussed in section 5.3, pollutants adversely affect the health of aquatic ecosystems by negatively impacting aquatic organisms and disrupting the food web due to bioaccumulation of contaminants. The most effective method of reducing pollutant levels in water bodies is to limit the use of these substances in the surrounding watershed, particularly in areas adjacent to the water body. The establishment or enhancement of wetland vegetation and/or riparian buffers will improve water quality by intercepting, filtering, and removing pollutants before reaching local waterways. Maintaining vegetated riparian buffers serves many important functions in protecting wetlands and water quality. Stabilizing stream banks and shorelines with vegetation will reduce erosion and sedimentation rates. In addition, riparian buffers are critical for dissipating stream energy associated with high water flows, filtering sediment and pollutants, improving floodwater retention and groundwater recharge, providing habitat for in-stream and upland species, and supporting biodiversity (USEPA 1993).

5.9.1 MANAGEMENT GOALS AND OBJECTIVES

LaRC should expand and encourage the use of riparian buffers with the following goals:

- Avoid and minimize impacts to undisturbed forest and wetlands to the fullest extent practicable;
- Maintain undisturbed naturally vegetated buffers of at least 100 feet in width around all on-site wetlands and on both sites of all perennial and intermittent streams;
- Chesapeake Bay TMDL compliance credit for riparian buffers; and
- Increase habitat and recharge groundwater through increasing riparian buffer habitat.

5.9.2 MISSION AND MANAGEMENT ISSUES

The following are mission or management issues associated with riparian buffers:

- Maintenance of existing riparian buffers;
- Limited funding for riparian buffer planting projects; and
- Limited availability for riparian buffer locations.

5.9.3 GUIDELINES AND RECOMMENDATIONS

Wetlands are especially important for wildlife habitat, and surrounding buffers of natural vegetation aid in the breakdown of pollutants from stormwater runoff. The wider the riparian buffer is, the greater the reduction of pollutants. Buffers of 60 feet or more will make a greater contribution to controlling pollutants and should be the minimum wherever possible. For maintaining good wildlife habitat in a wetland, as well as controlling pollutants, a riparian buffer of 300 feet is preferable. Decisions on the buffer will depend on the type of pollution, slope, soil type, vegetation and the value of the wetland as wildlife habitat.

LaRC should work with the Virginia Department of Forestry when evaluating tree costs and species, and ideal planting techniques for scope of work development. All bare-root seedlings should be protected with a solar tree tube to shelter the seedling during early growth. Additionally, the tree tube should have bird exclusion netting across the top of the tube to prevent birds from being trapped within the tubes.

Reforested areas act as riparian buffers to protect local waterways, provide valuable habitat, reduce soil erosion, improve water quality, reduce runoff, and recharge groundwater. Reforestation projects should follow the Chesapeake Bay TMDL Guidance Document Table V.F.2, which recommends a minimum of 400 seedlings per acre to reclassify a land use change as forest land. LaRC should continue to evaluate areas that can be converted from mowed green space to no-mow reforested areas in riparian buffer zones.

5.9.4 MONITORING

Utilizing GIS, measure and track the extent of buffer riparian areas on NASA LaRC. Include buffer areas during initial stages of project planning.

5.10 INVASIVE AND EXOTIC SPECIES MANAGEMENT

Invasive species have negative impacts on the environment and natural resources, agriculture and food production systems, water resources, human, animal, and plant health, infrastructure, the economy, energy, and cultural resources. Of substantial growing concern are invasive species that are or may be vectors, reservoirs, and causative agents of disease, which threaten human, animal, and plant health.

EO 13112, "Invasive Species" called upon executive departments and agencies to take steps to prevent the introduction of invasive species, and to support efforts to eradicate and control invasive species that are already established. EO 13112 also created the NISC to oversee implementation of the order and encourage proactive planning and action by other federal agencies. EO 13751, "Safeguarding the Nation from the Impacts of Invasive Species" amends EO 13112 and directs actions to continue coordinated federal prevention and control efforts related to invasive species. EO 13751 maintains the NISC and incorporates considerations of human and environmental health, climate change, technological innovation, and other emerging priorities into federal efforts to address invasive species. Moreover, the Federal Noxious Weed Act of 1974 requires each federal agency to develop a management program to control noxious weeds on Federal lands under the agency's jurisdiction.

The detection and control of invasive species is a primary management concern of federal agencies, including NASA, because of the potential impacts invasive species have on environmental stability and the degradation they can cause to the natural environment. In 2005, NASA joined the National Invasive Species Council (NISC) to assist federal agencies to combat invasive species by providing information from satellites (NASA 2005b). NASA has aided the NISC in identifying saltcedar (*Tamarix* spp.), cheatgrass (*Bromus tectorum*), Canadian thistle (*Cirsium arvense*), and numerous aquatic species infestations throughout the United States (NASA 2006).

5.10.1 MANAGEMENT GOALS AND OBJECTIVES

The overall goal of invasive species management is to protect ecosystems and native plant and animal species from invasive species through compliance with EO 13112. Specific goals include the following:

- Identify actions that may affect the status of invasive species;
- As practicable, use programs and authorities to prevent the introduction of invasive species, detect, monitor and control invasive populations, and restore native species and habitat conditions;
- Not authorize or carry out actions that will promote the introduction or spread of invasive species;
- Eradicate invasive species using methods that will cause the least disturbance of native species that might be present; and
- Promote the use of native species in landscaped areas.

5.10.2 MISSION AND MANAGEMENT ISSUES

LaRC has limited data on the type or number of invasive species that may be present on Center. Some of the invasive species that have been identified at LaRC are phragmites, trees of paradise, and mimosa trees. Learning more about which invasive species LaRC must manage is critical to this program goal. The U.S. Department of Agriculture (USDA) maintains a list of invasive species (https://www.invasivespeciesinfo.gov/plants/main.shtml).

5.10.3 GUIDELINES AND RECOMMENDATIONS

PHRAGMITES CONTROL

On the Coastal Plain of Virginia, *Phragmites australis* (common reed or Phragmites) is considered a serious management problem and has rapidly expanded into tidal wetlands along the Chesapeake Bay region (Pyke & Havens 1999). Stands of Phragmites in North America proliferate and decrease native biodiversity and quality of wetland habitat, especially for migrating wading birds and waterfowl species.

Phragmites provides habitat for mosquitoes by trapping freshwater from rain events, and creating structure for mosquitoes to lay their eggs. Mechanical removal, such as cutting, mowing, and disking, encourages the spread of Phragmites. The rhizomes remain, and new plants rapidly emerge. In disturbed sites, Phragmites dominates the area, choking out most native plant species. Herbicides can effectively reduce the amount of Phragmites-choked areas, decreasing the potential breeding areas available to mosquitoes.

Some disturbed portions of NASA LaRC property have become overgrown with Phragmites. This common reed grows throughout the area in dense stands that are up to ten feet high and difficult to penetrate. Phragmites can be detrimental to wildlife. The uncontrolled proliferation of this reed is a problem in many wildlife habitat areas due to reduction of food and habitat for waterfowl. Consequently, several jurisdictions have devised control methodologies for Phragmites control. Project specific information is located in Appendix I.

The recommended action is to apply herbicides to stands of Phragmites and follow with mechanical removal or burning of dead stalks. The following subsections list the alternatives considered.

Aerial Spray Only - Aerial application has proven very effective (90 percent or more) initially, however treated areas require follow up herbicidal treatment (annually or bi-annually) or the Phragmites reinvades and propagates at the same or slightly lower rate prior to treatment. Additionally, in areas thickly inhabited by the Phragmites, the dead stalks remain making it difficult for other native species to propagate and thus, negatively impact the coastal watershed. The cost of aerial application is approximately $150-300 per acre.

Burn Only - Prescribed burns do not reduce the growing ability of the Phragmites unless the roots are burned. It is difficult to successfully burn the roots because a layer of mud, soil and/or water usually covers the rhizomes. Burning does destroy dead stalks providing other vegetation an

opportunity to grow, but also encourages more rapid new growth from the unaffected rhizomes. Fires in Phragmites stands can be dangerous because this species can cause spot fires more than 100 feet away from the primary burn area.

No Action Alternative - There would be no treatment (herbicide, prescribed burn or mowing) applied to the sites. The Phragmites would continue to propagate and spread, negatively impacting the ability of indigenous species to exist and flourish. Mosquitoes would continue to thrive in these areas.

Repeat Harvesting (Mowing) - Mowing alone is not a feasible choice because it does not kill the plant; it only removes the vegetative portion without impacting its roots. The roots will sprout in the following season. This option does not meet the needs of the Center of controlling the spread of Phragmites.

Smothering Using Black Plastic - Use of this option would be very costly, unsightly and would require coverage of relatively large areas. The plastic must cover the entire area infested with Phragmites for a minimum of three growing seasons for it to be effective at killing the roots (Ailstock et al. 1999). Even after the plastic is in place, new growth may punch through letting light back into the covered area. In hot summer months, the plastic will increase the soil temperature thus killing other desirable plant roots and soil organisms. In short, this method does not meet the needs of the Center by eliminating any benefit to the environment and may do more harm than an herbicide application.

Removal by Excavation - Phragmites deeply penetrates many soils and for proper control all Phragmites must be removed. This is very expensive and will only be effective if all underground portions are removed during excavation. Rhizomes have been observed over twenty feet below the soil surface.

Flooding the Infestation - Phragmites has not been controlled even when flooded for one year. It would be too difficult and costly to set up cofferdams to hold the floodwater in the areas that are infested with Phragmites. This doesn't meet the needs of the Center to control the spread of Phragmites since it would be too costly and not environmentally sound.

Biological Controls - There are no known biological controls for Phragmites at this time.

Herbicides – Two effective herbicides for Phragmites control include Glyphosate and Imazapyr. Appendix I contains detailed information on the use of these two herbicides.

USE OF NATIVE SPECIES

Native plant species should be selected, with feasible. When using a native plant species if not feasible for a planting area, ensure the selected species is non-invasive. The Virginia Department of Conservation and Recreation (DCA) maintains a list of Virginia native plant species (http://www.dcr.virginia.gov/natural-heritage/nativeplants).

5.10.4 MONITORING

Annual GIS mapping of existing Phragmites stands on NASA LaRC should be conducted and the desired treatment method should be implemented to help eradicate this species from areas where it has become the dominant plant species.

5.11 TREE AND PLANT MANAGEMENT

Though there is little potential for commercial forest management, forest resources do provide a number of social, environmental, and economic benefits including aesthetic enhancement, water quality improvement, and wildlife habitat. The primary policies and statutes that apply to forest management at NASA LaRC include NPD 8500.1, EO 12512 "Federal Real Property Management", EO 13112, and EO 13751.

Since 2009, LaRC has reforested over 3.5 acres with a mix of native hardwoods and pines. Many of these trees are strategically planted in areas around LaRC's nearby waterways. The trees act as riparian buffers to protect local waterways and provide valuable habitat. Furthermore, these projects are an inexpensive way for LaRC to earn "credits" toward pollution reduction goals for the Chesapeake Bay TMDL. Additional reforestation efforts are planned in the future in order to maximize groundwater absorption, improve water quality, and expand forested habitats.

LaRC also has a tree replacement strategy for trees removed during construction or demolition projects. For each tree removed, a combination of trees totaling the diameter at breast height (DBH) of the tree removed shall be planted.

5.11.1 MANAGEMENT GOALS AND OBJECTIVES

The overall goal is to sustain a healthy, natural ecosystem while supporting facility mission and provide for a range of social, economic, and environmental benefits. Specific goals include the following:

- Conserve and enhance the health and integrity of existing trees and plants that contribute to overall ecosystem function;
- Maintain a diversity of natural tree and plant ecosystems that support a full complement of native wildlife species;
- Provide an attractive, well-maintained working environment for facility personnel through the proper management and enhancement of landscaped areas;
- Enhance landscaped areas to better contribute to overall ecosystem function;
- Increase forested acreage through reforestation where practicable, within the constraints of LaRC's mission; and
- Maintaining LaRC Tree City USA certification.

5.11.2 MISSION AND MANAGEMENT ISSUES

The following is a bulleted list of LaRC tree and plant issues that need to be addressed and managed:

- LaRC has an aging tree population and several large tree specimens have been lost over the last several years. Currently, there is no Master Tree Plan or Master Landscape Plan;
- American elms on Langley Blvd have flagging indicative for Dutch elm disease or Elm Yellows;
- Damage resulting from construction and maintenance activities (e.g., gashes from weed eaters, mower damage, and root compaction/damage);
- Bacterial Leaf Scorch (BLS) management;
- Leaf loss on the sycamore trees;
- Little leaf lindens (*Tilia cordata*) may have leaf blight, causing brown spots. Leaf blight is caused by a fungus, so NASA LaRC may want consider treatment with a fungicide;
- The Hackberry trees are being affected by a leaf miner, resulting in prominent galls on the underside of the leaves;
- Landscape designs for the new buildings/parking areas do not incorporate native species;
- LaRC has challenges with species selection and tree quality for personnel who purchase and dedicate new memorial trees on Center; and
- Development of a LaRC Master Tree Plan is a low priority.

5.11.3 GUIDELINES AND RECOMMENDATIONS

PLANTING AND CARE

- Regionally native species should be used for the installation of new trees and plants. Planting should be done in accordance with nursery standards prepared by AmericanHort (ANSI Z60.1-2014). Online pdf is available at: https://cdn.ymaws.com/americanhort.site-ym.com/resource/collection/38ED7535-9C88-45E5-AF44-01C26838AD0C/ANSI_Nursery_Stock_Standards_AmericanHort_2014.pdf
- Implementation of standard BMP practices for construction activities and grounds maintenance that address tree and plant protection will improve the appearance, longevity, and overall health of the urban forest trees at the Center. The International Society of Arboriculture offers certification, training, and resources relating to standard practices for tree, shrub, and other woody plant maintenance, pruning, trimming, repairing, and removal of trees and shrubs. It is recommended that tree pruning is performed only by trained personnel or qualified tree care professionals.
- The care newly planted materials receive after planting is critical to their health and longevity. Ensuring adequate soil moisture immediately after planting and during the first 2 years of establishment is the key factor in planting success. Over-watering can deprive the tree air and should be avoided.
- Preventing damage from mowers and string trimmers is a significant problem for landscape managers. Wounds in a tree's bark make it more susceptible to disease and pest infestations and reduce its chance of survival. Several alternatives exist for reducing tree damage. Mulch

can be an effective method of protecting trees from mower damage, when used properly. Mulch protects trees by reducing weed growth around the plant's base, which reduces the need to mow near the plant. Mulch should be applied to a weed-free area around the root mat in a layer about 3 to 4 inches thick. Mulch should not be applied too close to the tree trunk or too deeply as this creates an environment that promotes fungal growth and decay.

- Placing trunk guards around the base of trees is another method of protecting them from mower damage. Flexible plastic trunk guards can be purchased from forest supply companies or homemade trunk guards can be made from hardware cloth. The plastic guards are more practical because they expand as the tree grows. Care must be taken to remove guards as trees grow as they can cause girdling and suckering when left in place too long.

DISEASE TREATMENTS

- For treatment of Dutch elm disease, trees can be treated with a fungicide called Arbortec, but this can be fairly expensive. NASA LaRC may consider sanitary pruning and monitoring. This is a top priority, as it will kill all of the remaining American elms on campus. Also, NASA LaRC needs to make sure any future installations of elms are DED resistant cultivars.
- Bacterial Leaf Scorch (BLS) management options are detailed here: https://www.apsnet.org/edcenter/disandpath/prokaryote/pdlessons/Pages/BacterialLeafScorch.aspx. There is no cure for BLS but NASA LaRC may consider sanitize pruning and/or removal.
- The leaf loss on the sycamore trees is caused by anthracnose, caused by the fungus *Apiognomonia veneta*. In order to help prevent the spread of anthracnose, NASA LaRC ground maintenance crews should clean up dead leaves on the ground and trapped in the crown of the tree because they carry the fungus.
- There is no need to prune loblolly pine trees unless it is deemed hazardous. Loblolly pines are generally good self-pruners.
- Fertilizing trees may accelerate the decline in stressed or damaged trees. Soil tests should be done before any fertilizer is applied to make sure the correct fertilizer and amounts are used under the current conditions.
- Leaf blight on Little Leaf Lindens is caused by a fungus, so NASA LaRC may want consider treatment with a fungicide.
- The galls resulting from leaf miners cause aesthetic injury but do not kill their host, thus control is usually not necessary. More information on Gall Psyllid management can be found at: https://lancaster.unl.edu/pest/resources/hackberrypsyllids.shtml.

OUTREACH AND INVOLVEMENT

- NASA Langley sponsors Earth Day/Arbor Day activities each year. This includes a variety of actives such as volunteer-based tree plantings and local educational tours. Additionally, personnel from SPEEB and invitees set up booths during Earth Day Expo to promote environmental activities and education on native plants. Once per year, environmental personnel at LAFB encourage participation in the regional Clean the Bay Day program. This

participation includes a weekend shore patrol to pick up trash from the LAFB shoreline. NASA LaRC encourages Center personnel to participate in these programs on LAFB or start their own programs and participation on these particular environmental days.

- NASA LaRC can utilize its public environmental website to make citizens and property owners aware of the sensitive nature of that land and ways they can reduce impact to those ecosystems.
- Increasing awareness of LaRC's Tree City USA designation and the roles trees play at LaRC.

5.11.4 MONITORING

NASA Langley should continue to receive reports from the grounds maintenance contractor on the number of trees pruned, removed, and planted annually. This information is used for Tree City USA applications and as an awareness to the overall health of trees on the Center.

It is also recommended that NASA Langley maintains a working partnership with a tree arborist to address disease and management issues with trees on NASA LaRC.

6.0 ENFORCEMENT

Due to the size of and limited access to the NASA LaRC property, it is not practicable or necessary to employ rangers or security personnel to patrol the land and enforce environmental laws and regulations. However, enforcement may be as simple as signage in areas that explain the natural resources present and a brief explanation as to why it should be protected.

SPEEB is also responsible for enforcement of natural resource compliance activities. Compliance is enforced through project planning and review, guidance documents, and site inspections and audits.

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Appendix I

Proposed Projects, Scheduling, Cost/Funding

Project Title
Tick Control - TickBot

Objective
Implement tick control and study tick-borne diseases present at LaRC through the use of a TickBot.

Background
The Old Dominion University (ODU) Tick Lab (https://sites.wp.odu.edu/tick-team/) is a continuation of a tick surveillance study of the Hampton Roads Area. The goal of the ODU Tick Research team is to increase awareness of the public and medical and veterinary professionals to ticks and tick-borne pathogens (bacteria, viruses and parasites that cause disease). One method for tick surveillance is through the use of the TickBot. The TickBot is a semi-autonomous, eco-friendly robot created to kill and collect ticks.

The TickBot works by using a magnetic sensor that follows a metal wire strung along the ground. Dry ice loaded into the TickBot is released as it crawls along, and the carbon dioxide it emits causes the ticks to grab onto a piece of cloth treated with pyrethrin, a pesticide that is non-toxic to humans. The ticks collected on the cloth are taken back to the ODU lab and tested for harmful pathogens that can cause disease. Additionally, the TickBot also protects an area by providing immediate relief from tick encounters for 24 hours.

In 2017, LaRC partnered with the ODU Tick Lab to test the TickBot at LaRC's Child Development Center (CDC), where ticks had been found on students. The CDC and its playground are surrounded by open field and forest, which are ideal tick habitats.

Project Description
Regular use of the TickBot at locations at LaRC could be used as a tick management strategy. Ideal locations would include highly populated areas near prime tick habitat, or high-risk areas (such as the CDC). Furthermore, a long-term TickBot study would provide data for tick-borne pathogens at LaRC.

Regulatory Drivers
EO 13112 (Invasive Species)

Implementation Schedule: Ongoing

Priority: Compliance

Funding Sources: NA

Cost Estimate: NA

Project Title
Bird Management – Osprey Nest Deterrent

Objective
Deter ospreys from constructing nests on man-made structures that could impact NASA LaRC missions or operations.

Background
Ospreys nest on many different types of man-made structures including buildings, cellular towers, boats, utility poles, and channel markers. At LaRC, osprey nests have also been found on tunnel structures, liquid nitrogen (LN2) tanks, communication towers, and other important structures. Ospreys are protected under the MBTA. It is unlawful to take, kill, or possess any osprey, including nests and eggs. Osprey nests found around LaRC can disrupt operations or research missions if there are eggs or young osprey present in the nest. Osprey nests can be removed without a permit if the nest is inactive. However, this can be avoided by deterring ospreys from constructing a nest on these structures.

Project Description
Utility companies recommend placing a relatively inexpensive plastic pipe cut in half, similar to the structure below, on top of man-made structures where ospreys are likely to build nests. The shape of the pipe does not allow the ospreys to create a stable nest.

Regulatory Drivers
EO 13112 (Bird Management), Migratory Bird Treaty Act

Implementation Schedule: Ongoing

Priority: Stewardship

Funding Sources: NA

Cost Estimate: ~ $500 per pipe and installation

Project Title
Bird Management – Predator Control

Objective
Remove mammalian predators, including red fox, opossum, and raccoons to protect bird species.

Background
Red foxes are an exotic species and persistent nocturnal predators of bird colonies all along the Atlantic Coast. Red foxes will take eggs, chicks, and adults of most all ground nesting species. Raccoons are mainly upland predators and can also take both the eggs and chicks away from nests. Predation is a natural occurrence. However, when predator populations such as red fox have gone unchecked the impacts to nesting species have been significant. A predator control and removal program can be critical to the success of bird colonies.

Project Description
Contract with US Department of Agriculture, Wildlife Services to remove red fox, opossum, and raccoons from the Center to protect bird species of special concern. These problem species may be removed by sharpshooting and/or trapping.

Regulatory Drivers
EO 13112 (Bird Management)

Implementation Schedule: Ongoing

Priority: Stewardship

Funding Sources: NA

Cost Estimate: $5,000 for 10 days

Project Title

Bird Management – Eastern bluebird

Objective

Enhance nesting habitat for migratory birds.

Background

Appropriate habitat for nesting and brooding has declined for many bird species world-wide. Nesting habitat can be created or enhanced for a number of species; including bluebirds and purple martins, whose populations have been in decline, by the use of artificial nest boxes/hotels. Suitable foraging habitat for eastern bluebirds is abundant. However, because little nesting habitat is available, implementing a bluebird nest box program could benefit this species. Building and installing nest boxes is a popular activity for community members and conservation organizations and volunteer support may be available from the NASA community. Mapping nest box locations using global position systems (GPS) technology is important to relocating bird boxes for future monitoring and maintenance. All nest boxes must be placed in areas away from the airfield to avoid increasing BASH potential.

Project Description

GPS all existing and new nest boxes. Install bluebird nest boxes in appropriate habitat on NASA LaRC in accordance with guidelines as summarized from the North American Bluebird Society (http://www.nabluebirdsociety.org/nestbox-plans/).

THE BLUEBIRD BOX

- A good bluebird box should be well ventilated, watertight, have drainage holes, be easy to monitor, and easy to clean.
- Cedar and redwood are ideal, although plywood and other types of wood can be used.
- Treated lumber should not be used because of its toxic content.
- A bluebird box should never have a perch. Sparrows and wrens are attracted to perches.
- Boxes for Eastern Bluebirds should have a round entrance hole of 1 1/2" or oval of 1 3/8" x 2 1/4".

SETTING UP A BLUEBIRD TRAIL- suitable habitat should include perch sites, such as a fence line, wires, or tree branches where bluebirds may perch to search for food.

- Mowed areas away from human traffic are all good locations for a bluebird trail.
- Avoid brushy and heavily wooded areas -- this is the habitat of the House Wren.
- Avoid areas where the House Sparrow is abundant (i.e., urban areas).

MOUNTING THE BLUEBIRD BOX- Mount nesting boxes so the entrance hole is approximately 5 feet above the ground. If possible, face the box away from prevailing winds and facing towards a tree or shrub that is within 100 feet of the box. Trees and shrubs provide a landing spot for the young bluebirds when they first leave the box.

- Smooth round pipe is probably the best and simplest mounting system to use - 3/4" electrical conduit works well, but any smooth scrap round pipe will also work.

- Coating the pole with grease will also help to keep predators off the box.
- Hardware cloth placed under a box helps to prevent snake predation.
- Avoid mounting bluebird boxes on a fence line or on trees. Raccoons are known to walk fence lines and may find your boxes.

Nesting density for bluebirds is dependent on factors such as population density, habitat suitability, individual tolerance levels, and visibility between boxes. The following distances are given as general guidelines only. Eastern Bluebirds - 125 to 150 yards. Boxes can be mounted in pairs in areas where Tree Swallows are abundant. When paired, boxes should be mounted 5 to 25 feet apart. This provides nesting sites for both species and helps to prevent competition between them.

MONITORING A BLUEBIRD TRAIL

Do not put up a bluebird box if you do not plan to monitor it. Check your bluebird boxes at least once a week during the nesting season, until chicks are close to fledging.

- Do not open the box after nestlings are 12 to 14 days old. Doing so could result in the nestlings leaving the box before they are able to fly, greatly reducing their chance of survival.
- Always remove House Sparrow nests immediately.
- Have your bluebird boxes in place by mid-March when the bluebirds return from their winter migration and are looking for nesting sites. However, boxes may also be put up later in the nesting season.
- Bluebirds usually nest in late March or early April, depending on weather conditions.
- Bluebirds usually have two broods per season, but three broods are possible.

RECOGNIZING A BLUEBIRD NEST

- Nests are cup-shaped and are usually made up of 100 percent woven grass or pine needles.
- Bluebirds usually lay 3 to 5 light blue eggs, but may lay as many as 6 or 7. A small percentage of their eggs may be white.
- The incubation period for bluebird eggs is 12 to 14 days.
- Nestlings remain in the nest 18 to 21 days before they fledge.

Remove bluebird nests and those of other birds as soon as the young birds have fledged. Keep records of the activity on your bluebird trail. This information is valuable to the North American Bluebird Society (NABS), a non-profit organization, which compiles data on bluebird populations in North America. Annual Nesting Report Forms are available from NABS.

Regulatory Drivers
MBTA, NPD 8500.1

Implementation Schedule: Annual

Priority: Stewardship

Funding Sources: N/A

Cost Estimate: $2,500 for materials and set up

Project Title
Bird Management – Wood duck

Objective
Enhance nesting habitat for migratory birds.

Background
Appropriate habitat for nesting and brooding has declined for many bird species world-wide. Nesting habitat can be created or enhanced for a number of species, including wood ducks. Suitable foraging habitat on and around NASA LaRC for wood ducks is abundant. However, because little nesting habitat is available, implementing a wood duck nest box program could benefit this species. Mapping nest box locations using global position systems (GPS) technology is important to relocating nesting boxes for future monitoring and maintenance. All nest boxes must be placed in areas away from the airfield to avoid increasing BASH potential.

Project Description
Nest boxes can be placed either on land or over the water. If located over the water, they should be placed at least 4 feet above the high water level and the entrance hole should face the open water rather than the shoreline. Because of ease of access by predators, installation of nest boxes directly on trees should be avoided. Nest boxes placed on land should be located from 30 to 150 feet away from the shoreline. Boxes placed directly on the shoreline appear to be more likely frequented by nest predators. Since the hen must lead her ducklings to water soon after they hatch, the area between the nest box and the water's edge should be free of any major obstacles such as roads or fencing. Nest boxes placed on poles over water are generally easier to monitor than those placed in trees. Regardless of whether the box is placed over the water or land, the entrance should be clear of obstructions to provide easy access for the ducks.

Nest boxes should be constructed of a weather-resistant wood; cedar or cypress is recommended. The wood can be painted, stained, or treated, but only on the outside surface. The entrance hole should have a 4-inch diameter or be an oval that is 3 inches high and 4 inches wide. Numerous nest box designs have been used with success. A 3-inch wide strip of 1/4-inch mesh hardware cloth should be securely fastened to the inside of the box under the entrance to function as a ladder for the hen and newly hatched ducklings. The cut edges of this cloth should be folded back before insertion to avoid injury to the ducklings. Another method of assisting the ducklings in their climb from the nest to the entrance hole is to roughen up the wood surface under the hole with a chisel. A minimum 3-inch layer of coarse sawdust should be placed at the bottom of the box to serve as nesting material and to help prevent the eggs from rolling around. The lid or one side of the box should be removable to facilitate monitoring and cleaning. All wood duck boxes should be fitted with a galvanized sheet metal predator guard. The predator guard should be placed 6 to 12 inches below the bottom of the box.

In order to maximize nest box use while minimizing nest dumping, it is generally recommended that nest boxes should be placed at least 600 feet apart and should not be visible to one another. When placing nest boxes in isolated locations, consider ease of access for monitoring purposes. Before nesting boxes are erected, a maintenance and monitoring plan to ensure the success of the program

should be developed. Old nests must be cleaned out regularly if the boxes are to be used more than once during a nesting season. The monitoring program should ensure that boxes are monitored at least once before the beginning of the nesting season, and should be checked at least once a month during the nesting season if multiple uses of nest boxes per nesting season are desired. Boxes should remain out during the winter to provide winter cover sites for screech owls and other resident birds.

Regulatory Drivers
MBTA, NPD 8500.1

Implementation Schedule: Annual

Priority: Stewardship

Funding Sources: N/A

Cost Estimate: $100 for materials and set up per nesting box

Project Title
Deer Management - Tick Control

Objective
Implement tick control and Lyme disease through topical application of pesticides to whitetail deer.

Background
Whitetail deer are the preferred host for adult deer tick (*Ixodes scapularis*), which is the known vector of Lyme disease. The USDA has developed and patented a device for the topical application of pesticides to deer for the control of ticks. The device, called a 4-poster deer treatment bait station, has paint rollers mounted on each corner that apply pesticide to the head and neck areas while deer feed from two troughs containing corn. Studies show that the use of the 4- poster bait station with approved tickicide has resulted in control of 92 to 100 percent to of ticks after 3 years of use with approved tickicide (Solberg et al. 2003). The EPA has approved a specially formulated 10 percent permethrin based tickicide for use in treating ticks on deer.

Project Description
Purchase and install up to eight 4 poster deer treatment bait stations. To initially attract deer to the stations, disperse extra corn and apple slices along trails leading to the stations. Fill each bait station with 225 pounds of whole, shelled corn. The 4-poster bait stations should be maintained on a year-round basis other than periods when temperatures are below freezing. The rollers should be treated with 15 ml of 10 percent permethrin solution. Retreat the rollers approximately two times per week and after inclement weather. The trough plates should be closed before and during inclement weather to prevent moisture from entering and causing molding and caking. To assess the effectiveness of tick control efforts, tick sampling should be conducted prior to implementing this program. Two techniques to sample for ticks are recommended: (1) dragging cloth flags over vegetation or (2) collecting from the investigator's clothing. Flagging for ticks involves using a cotton flannel or other fabric attached to a wooden pole. The cloth is either hung at one end in a flag configuration and dragged, or is attached to the middle and dragged by rope tied to each end of the wooden pole. The use of flags is the preferred method when collecting larval and nymphal *Ixodes* ticks as it samples host- seeking ticks in the leaf litter over a quantifiable distance or exposure. Collecting ticks from the investigator while walking involves wearing cotton pants tucked into socks, and the collector removes attached ticks periodically while walking through the sampling area. This latter method is particularly effective for sampling adult ticks (Patnaude and Mather. 2007).

Regulatory Drivers
EO 13112 (Invasive Species Management)

Implementation Schedule: Ongoing

Priority: Compliance

Funding Sources: N/A

Cost Estimate: $8,500 first year (Materials only); $4,000 annually (Materials only)

Project Title

Nuisance Species Management - Mosquito Control

Objective

Implement mosquito control and surveillance to reduce mosquito populations and the risk of mosquito borne diseases.

Background

An effective mosquito surveillance program provides an estimate of species abundance and distribution. Data collected is used to estimate risk levels, guide control operations, and evaluate various control methods.

The following objectives serve to obtain the necessary information about local mosquito populations:

1) Identifying the mosquito species that are present;
2) Identifying the mosquito species that are the cause of local citizen complaints, and determining whether they are important West Nile Virus (WNV) vector species;
3) Identifying and mapping mosquito breeding habitats for larval control purposes;
4) Defining the geographic area that needs to be treated to control adult mosquitoes;
5) Estimating the desired trigger threshold (population density) for initiating control;
6) Determining when local mosquito populations are at an appropriate developmental and/or behavioral stage to apply control measures;
7) Determining the effectiveness of local mosquito control measures;
8) Determining whether vector mosquito species are present in an area, and whether they are infected by WNV and/or other arboviruses;
9) Determining the mosquito infection rate (MIR) for WNV or other arboviruses in a vector species population; and
10) Determining the seasonal activity patterns of local mosquito species;

Project Description

Mosquito surveillance involves numerous different strategies and practices. A variety of different methods are used to trap mosquitoes in the field because different mosquito species have different behaviors and biology and cannot all be collected by the same method. For example, some mosquito species are readily caught in traps whereas other species are rarely collected in traps. Different types of traps are used for different species of mosquitoes. Also, larval mosquitoes occupy different environments than adult mosquitoes, so collection methods used for larvae are much different than those used for adults. For arboviral surveillance, appropriate species of adult mosquitoes should be collected, pooled and submitted to the laboratory for arboviral testing. Surveillance should be utilized for determination of arboviral risk as well as for planning, execution, and evaluation of control practices.

1. Larval Surveillance

Surveys of immature mosquitoes are an important aspect of the surveillance program, and for certain species, larval surveillance may be a more accurate measure of mosquito population density than

adult trapping. Larval surveillance is essential for the appropriate targeting of larval control methods. Larval surveillance should begin early in the season, even before adults are active to help identify the breeding sites of vector species so that larval control efforts can be targeted. Larval surveillance can be conducted as part of inspection and complaint investigation activities and is often done in conjunction with the application of larvicides for control. In areas where there is no baseline mosquito surveillance data, larval samples can be used to identify and map vector-breeding sites. This information can then be used to help in determining appropriate trap locations to monitor adult mosquito populations. Larval surveillance requires the use of minimal and inexpensive equipment. Equipment should include: a long handled dipper; a small soup ladle (for dipping into tires or small holes); a small white, plastic or enamel pan (to dump dip samples into for close observation and detection of very small larvae); a turkey baster (for sample transfer); Whirl-pak ® larval collection bags (for collection of larval samples); a tea strainer (used to pour off excess water to concentrate larval samples); and a shoulder bag (to carry equipment in). Accurate records should be kept of when and where larvae are collected.

2. Adult Surveillance

Because it is the adult female mosquito that carries and transmits diseases, many surveillance techniques have been devised to collect adult female mosquitoes to monitor or record their activities. Techniques include the use of trapping, mechanical aspirators, and documentation of mosquito activity through citizen complaints. Trapping is widely used, but day-to-day success may be variable due to variation in environmental conditions such as wind, air temperature, rainfall, and trap location. Several different types of traps are used and each type is used to trap certain species of mosquitoes. There are also certain mosquito species that will not be attracted to traps and which must be collected by some alternative means.

It is often advisable to use several types of traps (e.g., gravid traps and CDC-light traps) at a single trap site to collect a representative sample of the species active at that location. Data on the trapped mosquitoes should be maintained to create a historical record of mosquito species found in association with different habitats. Trapped mosquitoes that have been identified can either be logged into a computerized mosquito database, or may be logged onto a paper data sheet for future data entry.

3. Mapping and Analysis of Mosquito Surveillance Data

Surveillance activities should include locating mosquito breeding habitats and defining the geographic range (area) affected by adult mosquitoes from an identified habitat. Habitats and areas of adult activity can be marked on paper maps and used for reference when planning control activities. The use of Global Positioning System (GPS) devices is recommended for accurate mapping, and is indispensable for mapping with computer based GIS software. Use of GIS requires good surveillance data management. GIS mapping allows the incorporation of many map layers that include such information as: road layout, jurisdictional boundaries, human population density, aquatic and/or wetland habitat types, topography, aerial photography indicating vegetation zones, etc. These many map features can aid in the analysis of mosquito data, or in the planning of control programs.

4. Source Reduction

The alteration or elimination of mosquito larval habitats is the most effective and economical method of providing long-term mosquito control. In salt marshes, ditch plugs and other water control structures should be removed or modified to permit daily tidal inundation to occur. The daily tidal exchange eliminates mosquito breeding and eventually restores the area to a productive salt marsh. Open Marsh Water Management, which includes the selective excavation of ponds, pond radials, and ditches, is effective in eliminating mosquito-breeding sites and providing permanent habitat for mosquito-eating fish.

Removal of *Phragmites australis*, common reed, is an effective way of reducing mosquito-breeding habitats. Application of herbicides is necessary to maintain areas where Phragmites thrives. Mowing, burning, or mechanical removal alone only encourages the spread of this invasive plant.

5. Natural Predators

Mosquito-breeding habitats may be stocked with fish, such as mosquito fish (*Gambusia holbrooki*), to control mosquito larvae. Habitats where fish may be used to control mosquitoes include storm water retention ponds and stagnant ditches. Other fish species, such as fathead minnows, freshwater killifish, and certain species of sunfish may also be used to control mosquito larvae and pupae. Care should be taken to avoid stocking mosquito fish into areas that harbor game fish, as many larva-eating fish will also feed on game fish fry.

6. Pesticides

Residents should be provided accurate and precise advance information on when and where aerial pesticides will be applied so that citizens who wish to avoid exposure may take cover and/or take action to protect pets and domestic animals including managed honeybee colonies, and aquaculture projects. Among various methods of informing the public, such as the media, one of the easiest ways to provide this advance notice is to establish a telephone hotline, publicize its number and record daily updates. Broad scale, aerosol/fog insecticide applications that cover areas that have not been surveyed or determined to have active mosquitoes, are not in keeping with prudent IPM practices. Targeted, focused and limited aerosol/fog application should be based on sound, scientific surveillance indicators.

Pesticide application personnel, in particular, are at risk from direct toxic effects of insecticides, and proper precautions must always be taken when handling, mixing and applying pesticides. Equipment used for applying pesticides must be properly calibrated to dispense the pesticide according to label specifications. Whenever any pesticide is applied, the law requires that the directions outlined on the pesticide label be carefully followed.

A. Larvicides

Larval mosquito control targets immature mosquitoes in their aquatic habitat before they become flying, biting adults. In general, larval control is the most effective method of controlling some mosquito populations, has the least effect on non-target species, and is applied to the smallest area of the environment. For example, one can treat an acre of aquatic habitat to control mosquito larvae, but if one waits until the adults have emerged and dispersed, one may need to treat 500 acres to kill

the adults that emerged from that acre of habitat. The larvicides recommended for use to control mosquitoes include the following:

- Bacterial larvicides, such as *Bacillus thuringiensis* var. *israelensis* (a toxin from a killed bacteria), and *Bacillus sphaericus* (a live bacterial spore) can be used successfully in a broad range of freshwater habitats, but are somewhat unpredictable in salt marsh habitats. *Bacillus thuringiensis* (***Bti***) based larvicides are sold in a variety of formulations (liquid, granule or briquet) under a wide variety of trade names such as: Mosquito Dunks®, VectoBac™, Aquabac™, Bti Briquets™. ***Bti*** based larvicides are quite effective against members of most mosquito genera, but may be slightly less effective on members of the *Culex* genus. *Bacillus sphaericus* (***Bs***) based larvicides are sold under the trade name VectoLex™. ***Bs*** is highly effective against species in the *Culex* genus, but is not effective against Asian tiger mosquitoes and several other species of *Aedes* and *Ochlerotatus* mosquito species. ***Bs*** works very well in polluted water, where it may be self-perpetuating. Bacterial larvicides are most effective when used against mosquitoes in the 1st through 3rd larval growth stages, but will not control late 4th stage or pupal stage mosquitoes.

- Biochemical larvicides, which contain an insect growth regulator called methoprene, are sold under the trade name Altosid®. Methoprene is an insect hormone that prevents immature mosquitoes from developing into adults. Altosid® products are labeled for use in a wide variety of natural and artificial aquatic habitats and are effective for use in salt marshes. Altosid® is most effective when used against mosquitoes in the 1st through early 4th larval growth stages, but is not effective against late 4th larval stage or pupal stage mosquitoes.

B. Adulticides

Adult control consists of two different techniques. One technique is the application of Ultra Low Volume (ULV) aerosols, or "fogging". The other technique is the application of "barrier treatments".

Aerosol/fog applications are the most widely used method of adult mosquito control and involve a volumetric treatment of air by the dispersal of very fine aerosolized droplets that are light enough to float on the air and be carried over a large area by wind. These small droplets (generally ranging from 1 to 40 microns in size) float on air currents and intoxicate the flying mosquitoes that are impacted by them. Fogs/aerosols are dispensed in very low doses (ounces per acre) and do not leave any significant residual pesticide layers on surfaces within treated areas. Aerosols and fogs generally only kill mosquitoes that are in flight because mosquitoes that are resting in sheltered areas are not impacted by sufficient numbers of droplets to get a toxic insecticide dose.

Ultra Low Volume (ULV) fogs and aerosols are generated with dispensing machines that physically split a liquid insecticide into very small droplets of a relatively uniform size (narrow size range). Most ULV machines can be set to produce droplets of a particular size within the 1 to 50 micron size range. The production of ULV aerosols/fogs does not require that the liquid insecticide concentrate be mixed with a carrier liquid such as oil or water, so a very small volume (ultra low volume) of liquid

insecticide can be converted into a fog/aerosol of relatively pure insecticide and be dispensed over a wide area.

Mosquito aerosol and fog applications should be made using properly maintained and calibrated ULV machines and foggers. Adulticide aerosol/fog applications may be made by equipment that is hand held, or mounted on backpacks, all-terrain vehicles, trucks, or on fixed-wing or rotary-wing aircraft. Aerial applications of mosquito control_insecticides are useful for rapidly treating large areas that cannot be easily accessed or covered in a timely manner by ground based spraying equipment. Due to the speed of coverage, the large area that can be treated, and the uniformity of the coverage, aerial applications are more effective in controlling mosquitoes than ground-based applications. Depending on the shape and size of the area to be sprayed, the advantages and drawbacks of using either fixed-wing or rotary-wing aircraft for dispersing pesticides should be considered.

Timing and conditions for adulticide aerosol/fog applications must be appropriate for treatments to be effective. Depending upon the target species, the greatest efficacy will be achieved when applications are made during periods when the target species is in flight. For example, *Culex pipiens*, a primary vector of WNV, is a nighttime biter, and applications should be made starting at dusk and continuing into the nighttime hours. The fogging of daytime flying mosquitoes can be difficult. Aerosol/fog applications made during daylight hours are often ineffective because warm convective air currents rising from close to ground level will carry the fine aerosol/fog droplets up into the sky. Daylight fog applications can be effective only when there are no convective currents and this may occur during early morning hours, on overcast days, or in heavily shaded areas. Fogging applications should be made when air temperatures are above 50° F because mosquitoes will not fly at lower temperatures. It is preferable to make fogging applications when wind speeds are from 3 to 5 mph. To avoid poor pesticide coverage due to excessive pesticide drift and dilution, fog applications should not be made when wind speeds exceed 10 mph. Applications should not be made from either ground vehicles or aircraft during periods of dead calm because the fog/aerosol will not be carried from the road or aerial spray swath into target areas.

Barrier treatments involve the application (spraying) of residual liquid pesticides on surface areas. A residual pesticide barrier applied to a surface can kill adult mosquitoes that subsequently land on the treated surfaces. Depending on the surface treated, and the occurrence of rain or other factors that might degrade a residual insecticide layer after treatment, residual barrier treatments may be effective for several days to several weeks after application. Barrier treatments are applied to foliage, vegetation, the eaves, ceilings and walls of houses, or any other place where adult mosquitoes are known to land and rest. Barrier treatments may be applied using a simple liquid insecticide sprayer with a fan nozzle, or may be applied using a ULV machine, thermal fogger, or air-blast fogger set to dispense mist-sized droplets in the 40 to 100 micron size range. Portable ULV machines are best used to apply barrier treatments to plants and foliage because small quantities of insecticide are used to apply a uniform layer of insecticide on a large area of foliage.

Regulatory Drivers
EO 13112 (Invasive Species Management)

Implementation Schedule: Ongoing

Priority: Compliance

Funding Sources: NA

Cost Estimate: $10,000 to 20,000 annually

Project Title

Nuisance Species Management - Resident Canada Geese Management

Objective

Maintain the resident Canada geese population at an appropriate level to reduce safety and health concerns and reduce BASH risk.

Background

Appropriate action is required on an as needed basis to provide adequate population management. The USDA APHIS WS has conducts Canada goose dispersal and lethal removal during the past 10 years. In order to meet wildlife management objectives, additional population control measures may be required.

Project Description

Manage resident goose populations warranting control from a safety and health perspective by continuing to contract with WS to remove birds. Nuisance goose control may also be conducted through reduction of resident goose populations. In accordance with the Nest and Egg Depredation Order of 71 FR 45964, which allows landowners to remove Canada geese in areas where they are causing conflicts with human populations, NASA personnel will locate Canada goose nests and addle the eggs using the approved Humane Society of the United States protocol. Under this order no permit is required, but NASA personnel must register with the USFWS in order to conduct this activity. Nests and eggs may be taken only between March 1 and June 30.

Regulatory Drivers

14 CFR 139.337

Implementation Schedule: Annual on an as needed basis

Priority: Compliance

Funding Sources: N/A

Cost Estimate: N/A

Project Title

Habitat Management – Longleaf Pine Establishment

Objective

Establish and manage stand of longleaf pines, eventually for use as a seed production area in corporation with the Virginia Forestry Department or NCRS.

Background

Longleaf pine forests once encompassed more than 90 million acres of the North American landscape. Today, only three percent, or 3.4 million acres, remain and, yet, Longleaf pine forests represent some of the world's most biologically diverse ecosystems. The Longleaf pine ecosystem provides critical habitat for 29 threatened and endangered species.

Longleaf pine has a number of economic, ecosystem and aesthetic values. Historically, it provided lumber, poles, ship masts, turpentine, tar and pitch. Longleaf pine forests are some of our most biologically diverse ecosystems; many species associated with longleaf ecosystems are threatened or endangered. Longleaf is highly resistant to pine beetles and fusiform rust; tolerant of wildfire and ice, and generally windfirm – longevity that translates into ecosystem stability and potential for long-term carbon sequestration.

Project Description

Long-term planning is the key to successful longleaf pine establishment and management. Site preparation, planting, competition control and periodic management practices (especially prescribed fire) are the key components to consider in the planning process. Having a schedule and description of activities can reduce costs and prevent mistakes.

Competitive woody stems, exotic grasses, soil types, and compaction are important considerations. Site preparation techniques include the single or combined use of herbicides, fire, and mechanical equipment. It is critically important to eliminate exotic grasses (e.g., Bermuda, fescue) before longleaf seedlings are planted. This is best accomplished by initially removing old thatch layer of grass with a winter prescribed burn. Treat with an appropriate herbicide during spring green-up and allow land to go fallow for one growing season before planting the seedlings the following fall.

Make sure seedlings come from a local source. Local varieties are site-adapted, exhibit better growth, and have improved disease resistance. Actively seek out vendors up to 1-year in advance of planting to ensure that quality seedlings are available in the quantity needed. Seedlings can be purchased as containerized or bareroot; however survival rates for containerized seedlings are typically higher. Optimum planting rates where wildlife is a primary objective are 605 trees (6’x12’) per acre or less. Divide the stand into manageable compartments with 30-60 ft wide firebreaks, and 2-5 ac wildlife openings throughout when designing layout to better facilitate future management. Seedlings should be planted during dormant late fall to early winter months when the upper 6 inches of soil is moist. To ensure seedling survival, it is critical to plant seedlings so that the terminal bud remains above ground level. The root collar of seedlings should be about ¼ inch beneath the soil surface when planted.

Regulatory Drivers
14 CFR 139.337

Implementation Schedule: Choose an experienced, reputable planter that will follow your design layout. Machine-planted stands will normally be in straight rows with exact spacing and larger numbers of seedlings can be planted with less manpower. Hand-planted stands tend to be more irregular in spacing, and often times, too many seedlings are planted on the site which can inhibit future access, decrease management potential, inhibit growth, and increase cost. Once seedlings are established, management needs should be addressed within the first two years. Stands should be prescribe burned as soon as possible after the first growing season and on a two to three year rotation thereafter. Burning helps control brown-spot needle blight, jumps seedlings out of the grass stage, improves wildlife habitat and helps reduce lateral limb growth, thereby improving wood quality. In addition to prescribed fire, thinning and final harvest are major management components. The timing and frequency of thinning is dependent upon site characteristics and management objectives, but as a rule of thumb throughout the life of the stand 30+ percent of the ground should be maintained in direct sunlight. Possible thinning should occur during winter so that resulting disturbances will promote favorable vegetative structure and forage for wildlife. Rotation age may vary, but long rotations offer greater management flexibility.

Priority: Stewardship

Funding Sources: N/A

Cost Estimate: N/A

Project Title
Wetlands and Riparian Buffer Management

Objective
Improve bottom habitat, water quality, and fisheries habitat benefits through wetlands restoration.

Background
Common reed (*Phragmites australis*) dominates tidal and nontidal wetlands at NASA LaRC extending from elevation approximately 0.8 ft to 6 ft along the shoreline.

Project Description
The tidal areas between elevation 0.8 ft and 1.0 ft should be planted with smooth cordgrass. High marsh species (*Spartina spp*.) should be planted between 1.0 ft and 2.0 ft. Phragmites will then be excluded from the low and high marsh areas by the dominance of these plantings, and their progreny. Tidal scrub/shrub species including marsh elder, groundsel tree, and wax myrtle should be planted between 2.0 ft and 3.0 ft in elevation. Riparian buffers between wetland areas and upland areas should be vegetated by shrub and herbaceous species,

Regulatory Drivers
14 CFR 139.337

Implementation Schedule: Install erosion and sediment control structures and remove Phramites along the shoreline. After excavation activities, verify and stake bottom elevations. Apply soil amendments to meet necessary pH and nutrient levels for seedlings. Plant the restoration areas and install goose exclusion fencing to protect new plants.

To the degree practicable, emergent tidal species are planted between March 1 and June 30 and woody species are planted while dormant (approximately November 1 through January 30).

Priority: Stewardship

Funding Sources: NA

Cost Estimate: $250,000 per acre

Project Title

Invasive and Exotic Species Management – *Phragmites australis*

Objective

Control target invasive species and prevent the further spread and degradation of natural habitats at LaRC.

Background

EO 13112 - Invasive Species restricts the introduction of harmful exotic species into native ecosystems, and to the extent practicable and permitted by law, to detect and control such species; accurately monitor invasive species populations; provide for restoration of native species and habitats that have been invaded; promote public education on invasive species, and conduct research on invasive species to prevent their introduction and provide for environmentally sound control.

EO 13751 - Safeguarding the Nation from the Impacts of Invasive Species amends EO 13112 and directs actions to continue coordinated federal prevention and control efforts related to invasive species. EO 13751 maintains the National Invasive Species Council, and incorporates considerations of human and environmental health, climate change, technological innovation, and other emerging priorities into federal efforts to address invasive species.

Project Description

At this time the most effective method of Phragmites control appears to be the use of the herbicide Glyphosate. This herbicide is found under several trade names as Roundup, Rodeo, Accord, and others. It is a general use, non-selective herbicide that acts by absorption through the leaves and kills systemically by blocking the production of amino acids within the plant.

Glyphosate has been used for many years as an herbicide. Experience has shown that when used according to label directions glyphosate will not cause adverse effects to mammals, birds, aquatic organisms such as fish and shellfish, amphibians, insects, earthworms, soil microorganisms and other terrestrial arthropods. This herbicide has been used extensively for wildlife management without adverse impacts.

Application of glyphosate late in the growing season, followed by prescribed burning or mechanical removal of dead Phragmites' stalks is a widespread and successful approach of controlling Phragmites. Application of glyphosate is economical and will require follow-up removal of the dead stalks. Retreatment is usually necessary every 3-5 years.

Rodeo® herbicide (EPA Reg. No. 524-343, 53.8% glyphosate) should be applied aerially at the current recommended rate of 0.5% of active ingredient per acre, diluted with water. Approved adjuvants will be mixed with Rodeo® to enhance control and reduce drift. Application methods include aerial, truck, backpack or hand-held spraying; wiper application; frill treatment, and by cartridge injecting lance (E-Z-Ject®). The current recommended rate is approximately 0.3 to 4.0 pounds of the active ingredient applied per acre. Rodeo® is preferred over Roundup and Accord because of its approved use around aquatic areas.

Glyphosate does not have herbicidal properties once in contact with soil, and plant roots do not absorb it from the soil (USDOE-BPA, 2000). Glyphosate dissolves easily in water, and half-life in water ranges from 35 to 63 days (Weed Science Society, 1994). Glyphosate and the non-ionic surfactant recommended for use with Rodeo® do not readily evaporate, thus having a minor impact to air quality during or after the application. It has no significant potential to accumulate in animal tissues, or tissues of aquatic organisms (Malik, 1989). Because Rodeo® is a herbicide and its mode of action (preventing plants from producing an essential amino acid) does not occur in animals, it has little to no effect to fish, birds or mammals, and is practically non-toxic to aquatic invertebrates. It does not bioaccumulate in fish, birds, mammals, or invertebrates and thus does not become part of the food chain. There are minor effects of glyphosate formulations on humans and only those with direct contact with the herbicide (mixing, loading, or application). There are no reported cases of long-term health effects in humans.

Imazapyr, the active ingredient in Habitat®, is part of the imidazolinone family, which is manufactured by the BASF Corporation. Habitat® inhibits a plant-specific enzyme (not found in animals or humans) that causes vascular plants to stop growing and slowly die as their food and energy reserves are exhausted. Habitat® is effective at very low rates, which means there would be less chemical load on the environment when used at label rates. Habitat® helps replace older, higher-use rate products. The current recommended rate for Phragmites control is 4 to 6 pints per acre applied to actively growing, green foliage after full leaf elongation. Stands with substantial amounts of old stem tissue should be mowed or burned first, then treated when new growth reaches approximately 5 feet in height.

The EPA does not classify the inert ingredients of the imazapyr formulations as toxicological concerns to humans or the environment (USDOE-BPA, 2000). Required testing by the EPA determined Habitat® is practically nontoxic, with the exception of green plants. Habitat® is ideal in aquatic areas because it breaks down quickly in water. Due to potential soil uptake, application in upland areas can result in impacts to vegetation not directly sprayed.

Regulatory Drivers
EO 13112 (Invasive Species), EO 13751 (Safeguarding the Nation from the Impacts of Invasive Species, NPD 8500.1 (NASA Environmental Management)

Implementation Schedule: Annual

Priority: Compliance

Funding Sources: NA

Cost Estimate: $500-1000 /acre

Appendix II

Flora and Fauna at NASA LaRC

PARTIAL LIST OF WILDLIFE OCCURING AT LANGLEY RESEARCH CENTER

I. INTRODUCTION

The following lists detail the wildlife found on NASA Langley Research Center. They are based on the 2009 “NASA Langley Research Center Habitat Classification and Wildlife Survey Report” by Science Applications International Corporation (SAIC) and the 1995 "Baseline Biological Survey of Terrestrial and Aquatic Habitats at NASA Langley Research Center, With Special Emphasis on Endangered and Threatened Flora and Fauna" by Old Dominion University (ODU).

Amphibians	
Species	**Common Name**
Ambystoma opacum *	Marbled salamander
Plethedon cinereus +*	Red-backed salamander
Gastrophryne carolinensis *	Eastern narrow-mouth toad
Hyla cinerea +*	Green treefrog
Pseudacris triseriata *	Upland chorus frog
Rana utricularia +*	Southern leopard frog
+ Note: These species were identified/observed at LaRC during the 2009 SAIC Survey * Note: These species were identified/observed at LaRC during the 1995 ODU Survey	

Reptiles	
Species	**Common Name**
Chelydra serpentine +*	Snapping turtle
Kinosternon subrubrum *	Eastern mud turtle
Terrapene Carolina +*	Eastern box turtle
Malaclemys terrapin *	Northern diamondback terrapin
Eumeces fasciatus +	Five-lined skink
Sceloporus undulates *	Northern fence lizard
Lygosoma laterale *	Ground skink
Opheodrys aestivus +*	Rough green snake
Coluber constrictor *	Black racer
Elaphe obsolete *	Black rat snake
Nerodia spp. *	Water snake
+ Note: These species were identified/observed at LaRC during the 2009 SAIC Survey * Note: These species were identified/observed at LaRC during the 1995 ODU Survey	

BIRDS	
Species	**Common Name**
Cygnus columbianus *	Tundra swan
Branta canadensis +*	Canadian goose
Anas rubripes *	Black duck
Aix sponsa *	Wood duck
Oxyura jamaicensis *	Ruddy duck
Anas platyrhynchos *	Mallard
Anas discors *	Blue-winged teal
Podilymbus podiceps *	Pied-billed grebe
Phalacrocorax auritus +*	Double-crested cormorant
Ardea herodias *	Great blue heron
Casmerodius albus +*	Great egret
Leucophoxy thula *	Snowy egret
Bucephala albeola *	Bufflehead
Lophodytes cucullatus *	Hooded merganser
Cathartes aura +*	Turkey vulture
Coragyps atratus *	Black vulture
Accipiter striatus *	Sharp-shinned hawk
Buteo jamaicensis +*	Red-tailed hawk
Rallus longirostris *	Clapper rail
Porzana carolina *	Sora
Charadrius vociferous *	Killdeer
Scolopax minor *	American woodcock
Tringa solitaria *	Solitary sandpiper
Catoptrophorus semipalmatus *	Willet
Totanus melanoleucus *	Greater yellowlegs
Totanus flavipes *	Lesser yellowlegs
Larus Philadelphia +	Bonaparte's gull
Larus marinus *	Great black-backed gull
Larus argentatus *	Herring gull
Larus delawarensis +*	Ring-billed gull
Larus atricilla +*	Laughing gull
Sterna nilotica *«	Gull-billed tern
Sterna hirundo +*	Common tern
Sterna albifrons *	Least tern
Zenaidura macroura +*	Mourning dove
Columba livia *	Rock dove
Bubo virginianus *	Great horned owl
Strix varia *	Barred owl
Chaetura pelagic *	Chimney swift
Archilochus colubris *	Ruby-throated hummingbird
Megaceryle alcyon *	Belted kingfisher
Colaptes auratus *	Northern Flicker
Dryocopus pileatus *	Pileated woodpecker
*Melanerpes carolinus**	Red-bellied woodpecker
Dendrocopus villosus *	Hairy woodpecker
Dendrocopus pubescens *	Downy woodpecker
Sphyrapicus varius *	Yellow-bellied sapsucker
Tyrannus tyrannus *	Eastern kingbird
Myiarchus crinitus *	Great crested flycatcher
Contopus virens *	Eastern wood pewee

BIRDS	
Species	**Common Name**
Iridoprocne bicolor *	Tree swallow
Hirundo rustica *	Barn swallow
Cyanocitta cristata +*	Blue jay
Corvus brachyrhynchos +*	American crow
Corvus ossifragus +*	Fish crow
Parus carolinensis +*	Carolina chickadee
Parus bicolor *	Tufted titmouse
Certhia familiaris *	Brown creeper
Cistothorus palustris *	Marsh wren
Troglodytes troglodytes *	Winter wren
Thryothorus ludovicianus *	Carolina wren
Mimus polyglottus +*	Northern Mockingbird
Dumetella carolinensis *	Gray Catbird
Toxostoma rufum *	Brown thrasher
Turdus migratorius +*	American Robin
Hylocichla mustelina *	Wood thrush
Catharus guttatus *	Hermit thrush
Seiurus noveboracensis *	Northern waterthrush
Catharus fuscescens *	Veery
Sialia sialis +*	Eastern bluebird
Polioptila caerulea *	Blue-gray gnatcatcher
Regulus calendula *	Ruby-crowned kinglet
Bombycilla cedrorum *	Cedar waxwing
Sturnus vulgaris +*	European starling
Vireo griseus *	White-eyed vireo
Passer domesticus *	House sparrow
Vireo flavifrons *	Yellow-throated vireo
Vireo olivaceus *	Red-eyed vireo
Vireo philadelphicus *	Philadelphia vireo
Mniotilta varia *	Black and white warbler
Parula americana *	Northern Parula warbler
Dendroica petechia *	Yellow warbler
Dendroica caerulescens *	Black-throated blue warbler
Dendroica coronate *	Yellow-rumped/Myrtle warbler
Dendroica virens *	Black-throated green warbler
Dendroica striata *	Blackpoll warbler
Dendroica pinus *	Pine warbler
Dendroica discolor *	Prairie warbler
Dendroica palmarum *	Palm warbler
Protonotaria citrea *	Prothonotary warbler
Vermivora pinus *	Blue-winged warbler
Helmitheros vermivorus *	Worm-eating warbler
Vermivora ruficapilla *	Nashville warbler
Wislonia citrine *	Hooded warbler
Seiurus aurocapillus *	Ovenbird
Geothlypis trichas *	Common Yellowthroat
Setophaga ruticilla *	American redstart
Sturnella magna *	Eastern meadowlark
Agelaius phoeniceus *	Red-winged blackbird
Quiscalus quiscula *	Common grackle

BIRDS	
Species	**Common Name**
Molothrus ater +*	Brown-headed cowbird
Cardinalis cardinalis +*	Northern cardinal
Carpodacus purpureus *	Purple finch
Carpodacus mexicanus +*	House finch
Carduelis tristis *	American goldfinch
Sitta canadensis +	Red-breasted nuthatch
Pipilo erythrophthalmus *	Rufous-sided towhee
Ammodramus savannarum *	Grasshopper sparrow
Ammodramus henslowii *«	Henslow's sparrow
Spizella passerine *	Chipping sparrow
Zonotrichia albicollis *	White-throated sparrow
Melospiza melodia *	Song sparrow
Junco hyemalis *	Dark-eyed junco
Haliaeetus leucocephalus *«	Bald eagle
Pandion haliaetus +*	Osprey
Falco sparverius +*	American kestrel
Pelicanus occidentalis *	Brown pelican
Phasianus colchicus *	Ring-necked pheasant
Colinus virginianus *	Common bobwhite
Meleagris gallopavo +	Wild turkey
+ Note: These species were identified/observed at LaRC during the 2009 SAIC Survey * Note: These species were identified/observed at LaRC during the 1995 ODU Survey « Note: These species are either Federal- or State-listed as endangered or threatened, 2009.	

MAMMALS	
Species	**Common Name**
Didelphis virginiana *	Opossum
Blarina brevicanda *	Northern short-tailed shrew
Scalopus aquaticus *	Eastern mole
Procyon lotor +*	Raccoon
Lutra canadensis *	River otter
Sciurus carolinensis +*	Gray squirrel
Glaucomys volans *	Southern flying squirrel
Peromyscus leucopus *	White-footed mouse
Oryzomys palustris *	Marsh rice rat
Microtus pennsylvanicus *	Meadow vole
Ondatra zibethicus *	Muskrat
Mus musculus *	House mouse
Sylvilagus floridanus *	Eastern cottontail
Odocoileus virginianus +*	White-tailed deer
+ Note: These species were identified/observed at LaRC during the 2009 SAIC Survey * Note: These species were identified/observed at LaRC during the 1995 ODU Survey	

AQUATIC SPECIES COLLECTED IN THE NASA LANGLEY RESEARCH CENTER AREA (ODU, 1995)

Notes:

Collection sites
a - Mouth of Brick Kiln Creek
b - Cedar Point area
c - Tabbs Creek mouth
d - Back River channel
e - Channel between Tabbs Point and Tin Steel Point
f - Area adjacent to the stave south of Tabbs Point
g - Shallows between Stoney point and Mears
h - Back Landing

Months
A - April sample
J - June sample
S - September sample

1. Species caught within the Northwest Branch of the Back River and its contiguous creeks (ODU, 1995).

Species	Common Name	Site							
		a	b	c	d	e	f	g	h
Chasmodes bosquianus	Striped blenny					A			
Trinectes maculatus	Hogchoker	A, J, S	A	A, J, S	A, S	A, J, S	A	A, J	A, J
Cynoscion regalis	Weakfish	J, S		J, S		A, S		A	
Opsanus tau	Oyster toadfish	A		A, J, S	A, S	A		J	
Bairdiella chrysoura	Silver perch	A, J, S	A, S	A, S		A, J			
Urophycis regia	Spotted hake					A			
Leiostomus xanthurus	Spot	A, J, S	A, S	A, J, S	A, S	A, J, S	A, S	A, S	A, S
Micropogonias undulatus	Atlantic croaker	A	A	A	A	A, J	A, S	A	A
Paralichthys dentatus	Summer flounder			A		A, J			
Morone saxatilis	Striped bass	A, J	A	J	S				
Anchoa mitchelli	Bay anchovy	A, J, S	A, J, S	A, J, S	A, S	A, J, S	A, S	A, J, S	A, J, S
Microgobius thalassinus	Green goby					A			
Gobiosoma bosc	Naked goby					A, S			
Caranx hippos	Crevalle jack				S				J
Lagodon rhomboides	Pinfish							J	
Menidia menidia	Atlantic silverside		A, J	A, J	A, J				
Tautoga onitis	Tautog				S		A		
Orthopristis chrysoptera	Pigfish		S	S	S	S		J, S	

1. Species caught within the Northwest Branch of the Back River and its contiguous creeks (ODU, 1995).

Species	Common Name	Site							
		a	b	c	d	e	f	g	h
Sygnathus fuscus	Northern pipefish							J	
Pomatomas saltarix	Bluefish						J, S		
Peprilus triacanthus	Butterfish			J					
Prionotus carolinus	Northern sea robin						S		
Chaetodipterus faber	Atlantic spadefish	S	S						
Menticirrhus americanus	Southern kingfish	S	S						
Selene vomer	Lookdown	S	S						
Anguilla rostrata	American eel			J					
Brevoortia tyrannus	Menhaden			J					

***Notes*: <u>Drainages, Marshes, and Ponds associated with Brick Kiln Creek</u>**

1 - Pond: permanent pond in northwest corner of LaRC property
2 - Marsh: brackish tidal marsh surrounding Site 1
3 - Marsh Creek: natural tidal creek draining portions of Site 2
4 - Marsh: south of 12 Wythe Landing Loop (WLL), adjacent to Bldg 1258 (WLL)
5 - Pond: semi-permanent pond east of Garrett-Winder Cemetary
6 - Drainage: drainage ditch system originating in the forest on the west side of LaRC, emptying into Brick Kiln Creek
7 - Drainage: brackish tidal creeks emptying into Brick Kiln Creek behind Bldg 1157
8 - Drainage: small drainage area west of 20 Hunsaker Loop

<u>Tabbs Creek Feeder Drainage</u>

9 - Drainage: large freshwater drainage ditch east of Doolittle Rd, north of softball fields

<u>Drainage Stream</u>

10 - Stream: intermittent stream crossing the tract of pine woods in the southeast corner of LaRC property

2. Species caught within the fresh and brackish drainages and ponds on NASA/LAFB property (ODU, 1995).

Species	Common Name	Site									
		1	2	3	4	5	6	7	8	9	10
Fundulus heteroclitus	Mummichog							A, J, S			
Fundulus majalis	Striped killifish	A, J, S	A, J, S	A, J, S			A, J, S	A, J, S		A, J, S	
Lucanis parva	Rainwater killifish	A, J, S	A, J, S	A, J, S			A, J, S	A, J, S		A, J, S	
Gambusia affinis	Mosquitofish	A, J, S	A, J, S	A, J, S			A, J, S			A, J, S	
Anguilla rostrata	American eel						A				
Menidia beryllina	Inland silverside	A, J, S									
Lepomis macrochirus	Bluegill	A									

3. Benthic invertebrate species collected at NASA LaRC during October 1994 (ODU, 1995).

Phylum	Tabbs Creek	Back River	Brick Kiln Creek
Annelida	Class Polychaeta *Nereis spp*. Class Oligochaeta *Oligochaeta spp*.	Class Polychaeta *Glycinde solitaria* *Haploscolopus fragilis* *Heteromastus filiformis* *Nereis succinea* *Spiochaetopterus oculatus* Class Oligochaeta *Oligochaeta spp*.	Class Polychaeta *Nereis succinea*
Arthropoda	Class Crustacea *Cyathura polita*	Class Crustacea *Corophium spp.* *Lepthocheirus plumulosus* *Leptalpheus forceps*	Class Crustacea *Uca minax*
Nemertina		Class Nemertina *Nemertina spp*.	

PARTIAL LIST OF PLANT SPECIES OCCURRING AT LANGLEY RESEARCH CENTER (SAIC, 2009 AND ODU, 1995)

Trees

Scientific Name	**Common Name**
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Ailanthus altissima	Tree of Heaven
Albizia julibrissin	Silktree
Carya glabra	Sweet pignut hickory
Carya ovata	Shagbark hickory
Carya spp	Hickory
Celtis laevigata	Sugarberry
Cornus florida	Flowering dogwood
Crataegus viridis	Green hawthorn
Diospyros virginiana	Persimmon
Fraxinus pennsylvanica	Green ash
Juglans nigra	Black walnut
Juniperus virginiana	Eastern red cedar
Lagerstroemia spp.	Crapemyrtle
Ligustrum spp.	Privet
Liqiudambar styraciflua	Sweetgum
Liriodendron tulipifera	Tuliptree
Maclura pomifera	Osage orange
Morus rubra	Red mulberry
Nyssa sylvatica	Marsh blackgum
Paulownia tomentosa	Princess tree
Persea borbonia	Redbay
Persea palustris	Swamp bay
Pinus echinata	Short needle pine
Pinus taeda	Loblolly pine
Platanus occidentalis	Sycamore
Populus alba	White poplar
Prunus angustifolia	Chickasaw plum
Prunus serotina	Black cherry
Quercus alba	White oak
Quercus laurifolia	Laurel oak
Quercus michauxii	Swamp chestnut oak
Quercus nigra	Water oak
Quercus pagoda	Cherrybark oak
Quercus palustris	Pin oak
Quercus phellos	Willow oak
Quercus stellata	Post oak
Salix nigra	Black willow
Sassafras albidum	Sassafras
Ulmus americana	American elm
Ulmus rubra	Slippery elm

Shrubs

Scientific Name	**Common Name**
Amelanchier arborea	Common serviceberry
Aralia spinosa	Devil's walkingstick
Asimina triloba	Common paw paw
Baccharis halimifolia	Eastern false-willow
Callicarpa americana	American beautyberry
Carpinus caroliniana	American hornbeam
Cornus amomum	Silky dogwood
Euonymus americana	American Strawberrybush
Hibiscus moscheutos	Crimsoneyed rosemallow
Ilex opaca	American holly
Ilex verticillata	Gray common winterberry
Itea virginica	Virginia sweetspire
Iva frutescens	bigleaf sumpweed
Leucothoe racemosa	Gray swamp doghobble
Ligustrum sinense	Chinese privet
Lindera benzoin	Northern spicebush
Myrica cerfiera	Wax myrtle
Nandina domestica	Sacred bamboo
Persea borbonia	Redbay
Phragmites communis	Common reed
Rhus copallinum	Winged sumac
Rubus occidentalis	Black raspberry
Rubus spp.	Blackberry and Dewberry species
Sambucus canadensis	Elderberry
Viburnum prunifolium	Blackhaw

Woody Vines

Scientific Name	**Common Name**
Berchemia scandens	Alabama supplejack
Campsis radicans	Trumpet creeper
Lonicera japonica	Japanese honeysuckle
Lonicera sempervirens	Trumpet honeysuckle
Parthenocissus quinquefolia	Virginia creeper
Smilax bona-nox	Saw greenbrier
Smilax glauca	Cat greenbrier
Smilax rotundifolia	Roundleaf greenbrier
Toxicodendron radicans	Eastern poison ivy
Vitis labrusca	Fox grape
Vitis palmata	Catbird grape
Vitis rotundifolia	Muscadine

Herbs/Grasses

Scientific Name	**Common Name**
Acalypha virginica	Virginia threeseed mercury
Agrimonia spp.	Agrimony species
Allium canadense	Meadow garlic
Ambrosia artensisifolia	Ragweed
Apios americana	Groundnut
Apocynum cannibinum	Indian hemp

Scientific Name	Common Name
Arthraxon hispidus	Small carpgrass
Asclepias syriaca	Common milkweed
Asplenium platyneuron	Ebony spleenwort
Aster spp.	Aster species
Athyrium asplenioides	Asplenium ladyfern
Atriplex patula	Spear saltbush
Bidens cernua	Nodding beggartick
Boehmeria cylindrica	Smallspike false nettle
Botrychium dissectum	Cutleaf grapefern
Carex comosa	Longhair sedge
Carex digitalis	Slender woodland sedge
Carex hyalinolepis	Shoreline sedge
Carex lurida	Shallow sedge
Carex squarrosa	Squarrose sedge
Cicuta maculata	Spotted water hemlock
Commelina virginica	Virginia dayflower
Cryptotaenia canadense	Canadian honewort
Cyperus atrovirens	
Cyperus spp.	Sedge
Datura stramonium	Jjimsonweed
Desmodium glutinosum	Pointedleaf ticktrefoil
Desmodium paniculatum	Panicledleaf ticktrefoil
Distichlis spicata	Coastal saltgrass
Dryopteris spinulosa	Spinulose woodfern
Elephantopus tomentosus	Devil's grandmother
Elymus virginicus	Virginia wildrye
Elytrigia repens	Quack grass
Erechtites hieracifolia	Burnweed
Erianthus strictus	Narrow plumegrass
Eupatorium capillifolium	Dogfennel
Eupatorium coelestinum	Blue mistflower
Eupatorium fistulosum	Trumpetweed
Eupatorium perfoliatum	Common boneset
Eupatorium rotundifolium	Roundleaf thoroughwort
Eupatorium spp.	Joepyeweeds
Fimbristylis spadicea	Hhot springs fimbry
Galium aparine	Catchweed bedstraw
Galium circaezans	Licorice bedstraw
Geum spp.	Avens species
Goodyera pubescens	Downy rattlesnake plantain
Hydrocotyle spp.	Hydrocotyle species
Hypericum hypericoides	St. Andrew's cross
Impatiens capensis	Jewelweed
Iris virginica	Virginia iris
Juncus coriaceus	Leathery rush
Juncus effusus	Common rush
Juncus roemerianus	Needlegrass rush
Juncus spp.	Rush species
Lobelia siphilitica	Great blue lobelia
Lycopus virginicus	Virginia waterhorehound
Matelea carolinensis	Maroon Carolina milkvine
Menispermum canadense	Common moonseed
Microstegium vimineum	Nepalese browntop
Mikania scandens	Climbing hempvine

Scientific Name	Common Name
Mitchella repens	Partridgeberry
Narcissus jonquilla	Jonquil
Onoclea sensibilis	Sensitive fern
Ophioglossum vulgatum	Southern adder's tongue
Osmunda cinnomomea	Cinnamon fern
Osmunda regalis	Royal fern
Panicum spp.	Signalgrass species
Panicum virgatum	Switchgrass
Paspalum spp.	Paspalum grass
Peltandra virginica	Green arrow arum
Phytolacca americana	American pokeweed
Podophyllum peltatum	May apple
Polygonatum pubescens	Hairy Solomon's seal
Polygonum cespitosum	Oriental ladysthumb
Polygonum persicaria	Spotted ladysthumb
Polymnia uvedalia	Hairy leafcup
Polystichum acrostichoides	Christmas fern
Prenanthes spp.	Rattlesnakeroot species
Pteridium aquilinum	Bracken fern
Rumex crispus	Curly dock
Rumex verticillatus	Swamp dock
Sagittaria graminea	Grassleaf arrowhead
Sanicula gregaria	Clustered blacksnakeroot
Saururus cernuus	Lizard's tail
Scirpus americanus	American bulrush
Scirpus robustus	Alkali bulrush
Scleria minor	Nutrush
Scutellaria integrifolia	Helmet flower
Senecio aureus	Golden ragwort
Sisyrinchium mucronatum	Needletip blueeyed grass
Smilacina racemosa	Feathery false lily of the valley
Solidago altissima	Canada goldenrod
Solidago puberula	Downy goldenrod
Solidago rugosa	Wrinkledleaf goldenrod
Solidago sempervirens	Seaside goldenrod
Spartina alterniflora	Smooth cordgrass
Spartina cynosuroides	Big cordgrass
Spartina patens	Saltmeadow cordgrass
Specularia perfoliata	Clasping Venus' lookingglass
Sporobolus spp.	Dropseed
Stellaria media	Common chickweed
Thelypteris palustris	Eastern marsh fern
Tipularia discolor	Crippled cranefly
Uniola laxa	Slender woodoats
Verbascum blattaria	Moth mullein
Verbena urticifolia	White vervain
Verbesina occidentalis	Yellow crownbeard
Woodwardia areolata	Netted chainfern
Woodwardia virginica	Virginia chainfern