INTEGRATED NATURAL RESOURCES MANAGEMENT PLAN (INRMP)
FOR
NASA LANGLEY RESEARCH CENTER
HAMPTON, VA

2013

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PLAN YEARS
2013-2018

This document addresses the Norfolk District's initiative to develop an integrated natural resources management plan (INRMP) for the National Aeronautics and Space Administration Langley Research Center (NASA LaRC) in Hampton, Virginia. INRMPs are planning documents that allow Centers to implement landscape-level management of their natural resources while coordinating with various stakeholders. INRMPs provide a comprehensive approach to ecosystem management and provide for the management of natural resources, including fish, wildlife, and plants, and allow multi-purpose uses of resources. NASA LaRC currently does not have an INRMP for natural resources management on the Center. This document has been prepared in reference to *Sikes Act* of 1997 (Title 16 of the US Code [USC] Section 670a et seq.), but because NASA LaRC is not a military installation, this document does not adhere strictly to the Sikes Act regulation. This INRMP has been developed as a management tool that ensures operations and natural resource conservation strategies are integrated and consistent with good stewardship and legal requirements of any other applicable federal, State, and/or local laws and regulations. The signatures below indicate the mutual agreement of the parties concerning the conservation, protection, and management of the natural resources present at NASA LaRC.

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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 Title 14 of the Code of Federal Regulations (CFR), 1216.319 – Procedures for Implementing the National Environmental Policy Act (NEPA*)*, 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 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;
- 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 are the Sikes Act (16 United States Code [USC] §§670a-670o, as amended) and NASA Policy Directive (NPD) 8500.1 – NASA Environmental Management. Title II of the Sikes Act – Conservation Programs on Certain Public Land, authorizes the Administrator of NASA to plan, develop, maintain, and coordinate conservation programs that include, but are not limited to, specific habitat improvement projects and adequate protection for species of fish, wildlife, and plants considered threatened or endangered. NPD 8500.1 directs NASA to maintain environmental stewardship of assets, control over environmental responsibilities, and compliance with applicable legal and other requirements.

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 Air Act (CAA), Clean Water Act

(CWA), Coastal Zone Management Act (CZMA), the Sikes Act, Endangered Species Act (ESA), NEPA, and Migratory Bird Treaty Act (MBTA); Department of Defense Instructions (DoDI); 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 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 Environmental Office has primary day-to-day responsibility for natural resources management. The Environmental Office will would 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.

NASA LaRC's Head of the Environmental Office signs the INRMP, certifies the annual review of the INRMP as valid and current; or delegates the certification of the annual INRMP review to the appropriate designee, provides appropriate funding and staffing to ensure implementation of the INRMP and oversees the management of natural resources.

Various NASA contractors contribute to the success of the INRMP implementation, such as grounds maintenance and ROME.

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 INRMP should be made a component plan to the NASA LaRC Master Plan (http://gis-www.larc.nasa.gov/masterplan/Main_Page); 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 would be considered implemented when the NASA LaRC Environmental Office:

- 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 annually and coordinates annually with the proper federal, state, and local agencies, as deemed necessary,
- 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. Annual reviews conducted by LaRC Environmental Office 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 annual 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 fulfill its mission in a manner that promotes environmental stewardship, sustainability, and continual improvement, while mitigating environmentally driven mission risks.

LaRC has a well-established environmental management program. Managed by the LaRC Environmental Office, the program includes the following media areas: EMS, Sustainability and pollution prevention, Energy and water conservation, Waste management and disposal, Air

management and permitting, Water management and permitting, Hazardous material management, Storage tank management and spill prevention/response, National Environmental Policy Act (NEPA) conformance, Cultural and historic resource management, Environmental restoration and remediation, Recycling and reuse programs, Environmentally preferable purchasing, and Natural resource management.

LaRC Environmental Office staff interpret environmental regulations as they apply to LaRC's activities, provide guidance on regulatory requirements, act as the formal point of contact with all environmental regulation agencies, prepare and review environmental permits, coordinate remediation of contaminated sites, and monitor environmental compliance for LaRC's operations and projects. Additional information regarding NASA LaRC's Environmental Program found at: http://environmental.larc.nasa.gov

4.0 LaRC's OPERATIONS AND ACTIVITIES

Research and development activities at LaRC support the Agency programs in Aeronautics, Science, Exploration Systems, Education, and Innovative Partnerships. 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 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 would 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 and is available at: http://environmental.larc.nasa.gov/files/2013/03/LaRC-20-Year-Center-Revitalization-Plan.pdf

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).

5.1 Bird Management

Numerous species of birds, including waterfowl and wading birds, use the coastal marshes for foraging and/or roosting, including various species of herons, egrets, ducks, gulls, and geese. Species observed in Tabb's Creek along LaRC's northern property include the following: Caspian tern, great blue heron, green heron, osprey, herring gull, great egret, white ibis, Virginia rail, plover, killdeer, sandpiper, red-winged blackbird, and grey catbird.

In 2008, the US Fish and Wildlife Service released 'Birds of Conservation Concern' (BCC) in a continuing effort to assess and prioritize bird species for conservation purposes. This document can be used as a barometer of the condition of our 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. However habitat loss due to alteration or destruction continues to be the major reason for declines of many species. 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' (Clinton 2001). BCC species will also receive priority attention in the USFWS when allocating research, monitoring, and management funding." (U.S. Fish and Wildlife Service 2008) (Online version available at http://www.fws.gov/migratorybirds/) NASA LaRC is located in Bird Conservation Region (BCR) 30 – New England/Mid-Atlantic Coast. One hundred and thirty-four (134) bird species are listed for Region 30. Of these, two (2) species are regularly observed at NASA LaRC: Canada goose (*Branta Canadensis*) and common tern (*Sterna hirundo*).

There is an active bald eagle (*Haliaeetus leucocephalus*) nest on Langley AFB approximately 0.5 miles from the NASA LaRC property boundary. According to The Center for Conservation Biology Eagle Nest Locator webpage (http://www.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 2011. Therefore, it is likely bald eagles 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.

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 BASH, osprey counts and relocation, Bald Eagle management, etc.
- Promote the use of volunteer bird watchers on Center to help with data gathering on species.

5.1.2 Mission and Management Issues

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

- No current efforts for encouraging bird of concerns species 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 Bald and Golden Eagle Protection Act (Eagle Act) and the Migratory Bird Treaty Act (MBTA). 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 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.

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 Bird/Aircraft Strike Hazard (BASH) initiatives on Langley Air Force Base. Therefore, the attraction of bald eagles to the NASA LaRC property is not encouraged.

Nesting Boxes

Declining populations of bird species limited by suitable nesting habitat can be aided with artificial nesting boxes. Eastern blue birds 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 through Efficient Mowing

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 mowing 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 15th through August 15th 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 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 all together.**

5.1.4 Monitoring

The introduction of large populations of any bird species may conflict with the implementation of Bird/Aircraft Strike Hazard (BASH) initiatives on Langley Air Force Base. Therefore, it is recommended that NASA LaRC work closely with Langley AFB to ensure that any efforts to attract birds to the installation will not be in direct conflict with the BASH initiative.

To establish a bird monitoring program it is important to be consistent in 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 thru partnering with local birding groups. These groups are made up of a diverse group of 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, over browsing 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).

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;
- Avoiding 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 bulleted list of the most pressing deer management issues:

- Deer and auto collisions are an ongoing Center management issue. LaRC has a GIS-based map that tracks the number and locations of deer collisions on Center.
- In general, the average deer on Center appears undersized and very slim. The health of LaRC's deer herd is a real concern.
- Potential for Ticks and Lyme's Disease transmission. Currently, LaRC has no information on the abundance of ticks and/or the potential for Lyme's diseases transmission on Center.

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. 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.

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 Langley AFB. 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 facility, a joint partnership with Langley AFB is recommended. Excessive populations of the white-tailed deer herd are controlled, in part, by a restricted hunting program on Langley AFB. 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 Langley AFB. 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-borne diseases found in Virginia include:

- Two varieties of ehrlichiosis
- Lyme disease
- Rocky Mountain spotted fever

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. Tick control efforts in deer populations have been particularly effective using the USDA poster deer treatment bait station (Stolberg et al. 10 2003). Tick-borne disease and prevention information should be made available to NASA LaRC staff via a public brochure or poster campaign.

5.2.4 Monitoring

NASA LaRC currently has an agreement in place with the USDA Wildlife Services to conduct deer surveys on a regular basis. Any recommendations for management are made to NASA after the surveys.

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 the Environmental Office in order to track any trends the contraction of such diseases so that the proper control measures can be implemented as deemed necessary.

5.3 Water Quality and Fish Management

The tidal waters around LaRC serve as important spawning or nursery sites for many commercially and recreationally important species, which in turn supports to the regional economy. Fishing is not permitted at LaRC. No fish stocking or direct population management has been undertaken.

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.

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.

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.

- Conserve and promote conservation of game and nongame fish and their habitats.
- Encourage the growth of oysters in local creeks and rivers.
- Ensure that LaRC helps to restore water quality in the Chesapeake Bay.

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. 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 LaRC faces:

- Addressing the new Back River TMDL for bacteria (fecal).
- Addressing the new Chesapeake Bay TMDL for sediment, phosphorous, and nitrogen.
- Understanding the local fish population and how LaRC affects it.

5.3.3 Guidelines and Recommendations

Oyster Reef Restoration

Oyster reefs provide several services to the ecosystem. Their filtration removes suspended inorganic and organic particles, thereby reducing turbidity. This filtration represents a type of biomanipulation that helps counter the negative impacts of eutrophication (Lenihan and Peterson, 1998; Jackson *et al*., 2001). With reduction in turbidity, the consequent enhanced light penetration can allow SAV habitat to expand in depth range and in aerial cover because these rooted aquatic grasses are limited by light penetration. Such SAV expansion provides additional nursery habitat for fishes and crabs in the bay. Oyster reefs also serve as important habitat for crabs and demersal fishes, both through provision of structural refuges and also by promoting production of associated invertebrate prey organisms (Zimmerman *et al*., 1989; O'Beirn *et al*., 1999; Lenihan *et al*., 2001; Peterson *et al*., 2003). The overall impacts will be positive for the fauna of the surrounding waters. The establishment of a healthy oyster community will, in turn, promote usage by higher trophic level organisms. A study of the ichthyofauna of living oyster reefs in the Piankatank River, a small Chesapeake Bay sub-estuary, indicates that high species richness is associated with these reefs (Harding and Mann, 1999). According to Harding and Mann, success of lower trophic levels enhances production at higher trophic levels, thereby infusing the oyster reef with the resources to support a complex trophic network that has high potential for long-term productivity. The resulting increased productivity in the vicinity of oyster reefs may have ramifications for recreationally and commercially valuable finfish communities. More information is located in Appendix I.

There have been encouraging signs that native oyster restoration is beginning to work in some areas and the USACE constructed reefs in the Great Wicomico and Lynnhaven Rivers are examples of successful, self-sustaining projects.

Potential adverse effects associated with oyster reef construction and post-construction include direct encounters with aquatic life during placement of reef materials, substrate changes, and increased turbidity. The process of shell and/or additional substrate placement could adversely affect fish throughout the water column by direct encounters with falling materials during the placement process, as well as adversely affect benthic fauna by burial. Only those benthic organisms unable to avoid burial from placement will be impacted. It is anticipated that oyster reef restoration will contribute to the restoration of benthic population diversity and abundance. Most

shellfish beds in the area have been condemned for harvesting due to enterococci/fecal coliform contamination, so the reefs would be more protected from poaching.

The construction of oyster reefs in the Chesapeake Bay typically involves the use of “fossil” shells, which are oyster shells dredged from old reef footprints now covered by sediment. An alternative to dredging fossil shell is using fresh oyster shell from oyster shucking houses, as well as other marine derived shell as full substitutes for the fossil shell, based on availability. The preferred method for placing shells is using a front-loader to push shells off the barge into the water or a clamshell bucket to precisely place shells. Water cannons may be used if the contractor can demonstrate the shells are properly placed and contained within the construction design footprints.

5.3.4 Monitoring

Each reef should be monitored annually to include a general description of the oyster reef sites, site maps, and data from all samples taken. A monitoring report should include:

- Observations of wildlife or signs of wildlife observed at the site;
- Number and location of samples;
- Comparison of site conditions from the previous monitoring year;
- Oyster biomass for each reef;
- Total biomass for each reef;
- Number of oysters from samples in each size class (5 mm classes);
- Listing of additional species observed.

The shell portions of the reef can be sampled by simply placing a one meter square PVC marker over the survey area and excavating all live shell material from the survey plot and then processing the sample. In calculating oyster biomass on a reef, all living oysters within a square meter quadrant are removed. For ash free dry weight (AFDW), it's a three step process. First, wet weight is calculated by weighing the shucked meat only (the shell is discarded at the first step). Second, the meat is then dried at relatively low temp in an oven to get dry weight. The last step involves burning the oyster meat at high temp. This gets rid of all the organics in the sample, leaving behind just the non-burnable minerals that were in the tissues. AFDW is the difference between dry weight and the ash (Dry weight - ash weight = AFDW). AFDW is therefore the weight of the organic content of the sample which is the metric reported as biomass. AFDW will be estimated on a haphazardly selected subset of oysters of various size classes (5 mm size bins, similar to that done for the disease work) to derive an annual AFDW/length relationship for the oysters on the mitigation reefs. The random selection occurs before weighting and consists of selecting a number of oysters of each size class to obtain a representative sample. All oysters of a given size class are placed in a container and a certain number are randomly taken from the container.

Cow-nosed rays can be significant predators on oysters, in particular stocked oysters not firmly attached to the reef substrate. The best protection against cow-nosed rays is the establishment of

biogenic reefs. This is defined as a natural reef condition is for the oysters to be densely populated, firmly attached to the reef substrate, and oriented with the growing shell edges pointing upward. The result is essentially a sharp-edged limestone block of oysters. Cow-nosed rays cannot feed on oysters effectively when this natural reef configuration is established. To establish this will take recruitment and the long term development of an adult population and preserving the reefs as permanent sanctuaries. The initial spat-on-shell seeding will "jump start" this process of biogenic reef formation. In the event that monitoring indicates heavy predation, additional protective measures could include, but are not limited to, placing nets on reefs stocked with oysters, placing the oysters in biodegradable mesh bags, or use of cages and racks to protect large broodstock oysters during the spawning season temporarily, and then subsequently stocking them on the reefs. Such measures should only be needed during the time of year when cow-nose rays are active (May-September).

5.4 Nuisance Wildlife Management

Nuisance wildlife is wildlife that, because of their feeding or nesting habits, interferes with the facility mission or well-being of domestic animals, other wildlife, or humans. The most common nuisance animals currently at NASA LaRC include feral cats, squirrels, raccoons and foxes. Canada geese 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.

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 bulleted 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.
- How to best deter wildlife from the centralized-campus area.
- Mosquito Control
- Manage Canada goose populations if become a nuisance.

5.4.3 Guidelines and Recommendations

Nuisance Wildlife

Building occupants/users should contact the LaRC Environmental Office if nuisance wildlife exists in these areas. All nuisance wildlife incidents (whether real or perceived) shall be coordinated with the LaRC Environmental Office 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. The LaRC Environmental Office should continue to provide public outreach about wildlife and monitor areas where there is evidence of feeding these animals.

The Virginia Department of Game and Inland Fisheries (VFGIF) suggest some easy techniques which may solve the problem of nuisance and problematic wildlife and prevent them from re-occurring (www.dgif.virginia.gov/wildlife/problems/):

- If staff is feeding wildlife, tell them to stop because this will cause the animals 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.
- Soak a rag in ammonia and place the rag in or on the trash can(s) or building(s) that are the problem areas. The smell will discourage future visits. This technique will need to be repeated after rain.
- Moth balls placed in trashcans or around buildings will achieve the same results.
- 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, the Environmental Office shall coordinate with the USDA Wildlife Services for removal.

In 2000, Langley AFB contracted with the United States Department of Agriculture Wildlife Services (USDA-WS) to initiate a formal and aggressive Bird and Wildlife Aircraft Strike Hazard (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

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 storm water 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 coli form bacteria, and create excess nutrients in the surrounding water resources, which can lead to water quality problems. An increase in resident geese population also poses a threat to the numerous aircraft missions occurring daily at the facility. 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 b 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 that those birds would have to 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.

5.4.4 Monitoring

Nuisance wildlife issues and mosquito-borne disease 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 nuisance wildlife near buildings or the contraction of any mosquito-borne disease to the Environmental 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 and 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 SAIC and the facility-wide fish, wildlife, and plant surveys by ODU conducted in 1995. No plants, reptiles, amphibians, mammals, birds, or fish species listed as threatened or endangered were found in any of the habitat types at NASA LaRC.

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. It is most likely that threatened or endangered species occurring on the Center would be limited to seasonally present or transient bird species. 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.

As previously discussed above, there is an active bald eagle nest on Langley AFB approximately 0.5 miles from the NASA LaRC property boundary. Therefore, it is likely bald eagles 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.

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.

5.5.4 Monitoring

Around Christmas and again in the spring, the installation 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.

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 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 T/E habitat or known species.

5.6 Habitat Management

In 2009, the Science Applications International Corporation (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 3. The dominant habitat types consist of Developed and Maintained areas. Of the non-developed and non-maintained habitat, the majority consists of Coastal Plain Forest, of which there are seven habitat sub-categories. The flora at NASA LaRC is dominated by maintained areas consisting of mowed grass, shrubs, and ornamentals. The remaining areas of Coastal Plain Forest are dominated by hardwood, with evergreens being predominant in the southern forested area. Developed areas include man-made structures consisting of buildings, roads, sidewalks, parking lots, industrial equipment and various infrastructure facilities. Maintained Areas 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. This habitat type/classification has limited ability to support vegetation or other cover. Vegetation, if present, is widely spaced and scrubby.

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 key habitats needed by wildlife, protect and enhance them, and maintain a healthy ecosystem benefiting all species.

5.6.2 Mission and Management Issues

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

- Little planning is done to encourage and sustain habitats on Center.
- There are several locations on the grounds where the ground cover has been degraded by demolition and other activities.

5.6.3 Guidelines and Recommendations

- 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 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 is 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 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 in Appendix I.

- Prescribed Burning - 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 is 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 (BMP's) which can be viewed at the Virginia Department of Forestry's web site.

  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.

5.6.4 Monitoring

Existing land cover and habitat types are mapped at NASA LaRC by their 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 to over the next decade. In total, over 100 structures are planned to be demolished. The demolitions will results in reducing LaRC's footprint and establishing a centralized core campus.

5.7.1 Management Goals and Objectives

- Return areas to green space by removing all surface infrastructures to include building foundations and associated paving around the facility/structure.
- Use demolition areas for the construction of any required storm water management ponds.
- 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.)
- 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

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: 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.

Prior to planting, provide a firm, weed-free seed bed 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 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 Storm water Management Ponds/Retention Ponds: When a new construction project requires the creation of a storm water management pond, it is recommended that demolition areas be considered as the first alternative location. These areas have already been impacted and will help to prevent the loss of any additional forested or wetland habitat on the installation.

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 storm water management ponds.

5.8 Wetlands Management

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 Clean Water Act, Chesapeake Bay Preservation Act and Coastal Zone Management Act. Several federal and state laws and regulations reinforce the ecological and human health importance of maintaining healthy water bodies at NASA LaRC. Federal Compliance with Pollution Control Standards (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 storm water management programs for any action that may impact water quality. Project specific information is located in Appendix I.

Department of the Army permits are required under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) prior to commencing any work or building any structures in a navigable water of the United States. Under Section 404 of the Clean Water Act (33 U.S.C. 1344) discharge of dredge and fill material into waters of the U.S., including wetlands, is prohibited unless a Department of the Army permit is issued. Department of the Army permits are issued by the U.S. Army Corps of Engineers (USACE) Norfolk District Regulatory Branch. Furthermore, state and local agencies may also have jurisdiction regarding impacts to wetlands. Such agencies include Virginia Marine Resources Commission (VMRC), the Virginia Department of Environmental

Quality (VDEQ), the City of Hampton Wetlands Board. Construction and other activities that could potentially affect wetlands may require permits from these agencies.

Information on individual and state permit requirements and application procedures (including joint permit applications) is available on the Norfolk District website at http://www.nao.usace.army.mil/Missions/Regulatory.aspx .

Permits are requested by submitting a Joint Permit Application (JPA) coordinated through the LaRC Environmental Office 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, Protection of Wetlands, 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 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.

The VDEQ requires permits under the Virginia Water Protection Permit Program (Virginia Administrative Code 25-210) for any impacts to state waters and wetlands, including isolated wetlands. Activities requiring a permit include dredging, filling, or discharging any pollutant into or adjacent to surface waters, or otherwise altering the physical, chemical, or biological properties of surface waters, excavating in wetlands, or conducting any of the following activities in a wetland:

- Filling or dumping (to include vegetation debris such as from clearing and grubbing);
- Permanent flooding or impounding; and
- New activities that cause significant alteration or degradation of existing wetland acreages or functions.

5.8.1 Management Goals and Objectives

Overall goal is to comply with Federal, State, local and NASA regulations on wetlands management and protection. Specific goals include the following:

- Avoid or minimize impacts to wetlands to the greatest extent practicable

- 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

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

5.8.3 Guidelines and Recommendations

It is recommended that NASA LaRC obtain a full wetland delineation of the entire property either by the Corps of Engineers 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.

5.8.4 Monitoring

Continue to conduct biological surveys of the installation of terrestrial and aquatic habitats such as the biological survey conducted by Old Dominion University 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

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 would like to expand and encourage the use of riparian buffers.

- Chesapeake Bay TMDL compliance credit for riparian buffers

5.9.2 Mission and Management Issues

- Maintain or increase riparian buffers.

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 storm water runoff. Pollutants in runoff include nutrients in fertilizers, pesticides, and oil from parking areas. 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.

Pollutants adversely affect the health of water bodies by stressing fish and other aquatic organisms in the water column and in bottom sediments and lead to bioaccumulation and related food chain events. The establishment or enhancement of wetland vegetation and/or riparian buffers in these areas would be helpful for reducing pollutant input to water bodies on NASA LaRC. Excess nutrients in water bodies may cause algal blooms, increase nuisance plant growth and odors, disrupt species diversity, reduce dissolved oxygen levels, and cause human health impacts. 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.

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

The control of invasive species is a primary management concern of federal agencies because of the potential impacts invasive species have on environmental stability and the degradation they can cause to the natural environment. Invasive species detection and control are also NASA priorities. In 2005, NASA joined the National Invasive Species Council (NISC) to assist federal agencies 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 certain aquatic 36 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:

- Protect ecosystems and native plant and animal species from invasive plant species; and
- Eradicate new infestations of invasive species.
- Remove exotic species from naturalized areas and promote use of native species in landscaped areas.

5.10.2 Mission and Management Issues

Except for Phragmites, LaRC does not have a good idea of what invasive species are occurring at the Center. Learning more about which invasive species LaRC must manage is critical to this program goal.

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 II contains detailed information on the use of these two herbicides.

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, and EO 13112 – Invasive Species.

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; and
- Increase forested acreage through reforestation where practicable, within the constraints of LaRC's mission.
- 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.

5.11.3 Guidelines and Recommendations

- 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.

- The lack of post planting care and damage resulting from construction and maintenance activities is a common management issues. This should be another top priority because young trees are getting hit and gashed by weed eaters. 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.

- Implementing standard grounds maintenance practices that address protection of existing trees and shrubs would 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.

- Bacterial Leaf Scorch (BLS) management options are detailed here: http://gloucester.njaes.rutgers.edu/ag/pdfs/ag-blsofshadetrees.pdf . There is no cure, but NASA LaRC may need to 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 ground and trapped in 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 be accelerating decline in stressed or damaged trees. Soil tests should be done before any fertilizer is applied to make sure the correct fertilizer is used. Since fertilizer is available to plants in certain forms (nitrate/nitrite vs. ammonia) and under certain conditions, a significant portion of fertilizer will run off.

- 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 miner cause aesthetic injury and do not kill their host, so control is usually not necessary. More information can be found at: http://www.entomology.umn.edu/cues/Web/144HackberryNipple.pdf

- Installation of new trees and plants should use regionally native species.

- NASA Langley sponsor Earth Day/Arbor Day activities each year. Typically, trees are planted at various locations across the Center. Personnel from the environmental office and invited guests set up booths at the cafeteria to promote Earth Day-appropriate activities. Also, once per year, the Environmental Flight at Langley AFB sponsors Wing participation in the regional Clean the Bay Day program. This participation includes a weekend shore patrol to pick up trash and refuse from the Langley AFB shoreline. NASA LaRC could

request to participate in these programs on Langley AFB and prompt their participation throughout the Center or start their own programs and participation on these particular environmental days.

- NASA LaRC can utilize their own website or partner websites to make citizens and property owners abutting the Center aware of the sensitive nature of that land and ways they can reduce impact to those ecosystems.

5.11.4 Monitoring

Maintain working partnership with 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. The Environmental Branch is also responsible for enforcement of natural resource compliance activities.

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Appendix I

Proposed Projects, Scheduling, Cost/Funding

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 Fox 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
Sikes Act, 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/monitoring.htm).

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

Sikes Act, 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
Sikes Act, 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
Water Quality and Fish Management - Oyster Reef Restoration

Objective
Encourage the growth of oysters in local creeks and rivers.

Background
Oyster reefs provide several services to the ecosystem. Their filtration removes suspended inorganic and organic particles, thereby reducing turbidity. With reduction in turbidity, the consequent enhanced light penetration can allow SAV habitat to expand in depth range and in aerial cover because these rooted aquatic grasses are limited by light penetration. Such SAV expansion provides additional nursery habitat for fishes and crabs in the bay. Oyster reefs also serve as important habitat for crabs and demersal fishes, both through provision of structural refuges and also by promoting production of associated invertebrate prey organisms The establishment of a healthy oyster community will, in turn, promote usage by higher trophic level organisms. The resulting increased productivity in the vicinity of oyster reefs may have ramifications for recreationally and commercially valuable finfish communities.

Project Description
The construction of oyster reefs in the Chesapeake Bay and its tributaries typically involves the use of "fossil" shells, which are oyster shells dredged from old reef footprints now covered by sediment. Locally, fossil shell deposits are located in the James River. The fossil shells are dredged, placed on barges, and transported to the reef construction site. This practice of dredging buried shell to build and/or enhance oyster habitat has been going on for decades, beginning in the early 1960's. An alternative to dredging fossil shell is using fresh oyster shell from oyster shucking houses or recycling programs through restaurants, as well as other marine derived shell as full substitutes for the fossil shell, based on availability. The preferred method for placing shells is using a front-loader to push shells off the barge into the water or a clamshell bucket to precisely place shells. Water cannons may be used if the contractor can demonstrate the shells are properly placed and contained within the construction design footprints. Alternative materials that can be used in place of oyster shell include other marine shell (i.e. clam, whelk, sea scallop), granite, or crushed concrete.

Construction will consist of seeding with spat-on-shell oysters, as well as constructing 3-dimensional reefs (12 to 16 inches). The main objectives with the spat-on-shell plantings are: 1) augment biomass on the reef in order to help achieve a sustainable population; 2) augment recruitment on the reefs; and 3) accelerate disease resistance development by use of large, wild oyster stocks.

The proposed reefs will stand approximately 1 foot (12-16 inches) above the current bottom profile. In high-energy areas, particularly those portions of the reef likely to be exposed at low tide, the shells may be placed in biodegradable mesh bags (each bag holds approximately half a bushel of shell) prior to placement on the reef. This will help keep the shells in place prior to colonization with oysters. This technique has been used with considerable success along the East Coast, particularly for intertidal reefs in estuarine waters along the Atlantic coast in states further south than Virginia.

Regulatory Drivers
Sikes Act, 14 CFR 139.337

Implementation Schedule: Initial construction in early spring before oyster spatset. Potential annual adaptive management including additional seeding of oysters or additional reef material if siltation of reef occurs.

Priority: Stewardship

Funding Sources: N/A

Cost Estimate: $200,000 per acre

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 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. The 4-Poster Deer Treatment Bait Station was developed and patented by researchers at the USDA.

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 lb 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
Sikes Act, 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 Geographic Information Systems (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
Sikes Act, 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
Sikes Act, 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
Sikes Act, 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
Sikes Act, 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.

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. The Material Data Safety Sheet information for Rodeo® is included at the end of this Appendix.

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
Sikes Act, EO 13112 (Invasive Species), NPD 8500.1 (NASA Environmental Management)

Implementation Schedule: Annual

Priority: Compliance

Funding Sources: NA

Cost Estimate: $500-1000 /acre