

# Natural Resources Management Plan

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2018–2020



ANL-18/19



## Contents

<b>1.0 Purpose</b> .....	<b>1</b>
<b>2.0 Background</b> .....	<b>2</b>
<b>3.0 Define Land Use Areas</b> .....	<b>5</b>
<b>4.0 Natural Resources: Habitat Management Strategy</b> .....	<b>8</b>
<b>5.0 Goals and Objectives</b> .....	<b>12</b>
<b>6.0 Roles and Responsibilities</b> .....	<b>18</b>
<b>7.0 Implementation and Monitoring</b> .....	<b>19</b>
<b>8.0 References</b> .....	<b>20</b>
<b>Appendix A: Plant Communities of the Argonne Site</b> .....	<b>A-1</b>
<b>Appendix B: Ecosystem Management Units</b> .....	<b>B-1</b>
<b>Appendix C: Legislative and Regulatory Requirements for Natural Resource Management on Federal Lands</b> .....	<b>C-1</b>
<b>Appendix D: Site Landscape Plant List</b> .....	<b>D-1</b>
<b>Appendix E: Invasive Species Management</b> .....	<b>E-1</b>

## Figures

<b>1</b>	<b>Aerial view of the Argonne site today</b> .....	<b>1</b>
<b>2</b>	<b>Aerial image of the Argonne site from 1939 showing farmland, woods, and open space.</b> .....	<b>2</b>
<b>3</b>	<b>Relationships between Executive Orders, Congress, the U.S. Department of Energy, and the Argonne site.</b> .....	<b>3</b>
<b>4</b>	<b>The Hine’s Emerald Dragonfly, a federally endangered species documented at several locations on the Argonne site.</b> .....	<b>4</b>
<b>5</b>	<b>Argonne campus plan.</b> .....	<b>5</b>
<b>6</b>	<b>GIS map showing Ecosystem Management Units, their respective numbers, and their improvement with management.</b> .....	<b>7</b>
<b>7</b>	<b>Lessons learned process map.</b> .....	<b>9</b>

## Figures (Cont.)

8	<i>Phragmites australis</i> (common reed), an invasive plant species found on the Argonne site.....	10
9	Wetland on the Argonne site.....	11
10	<i>Trillium grandiflorum</i> (great white trillium). ....	12
11	<i>Rhamnus cathartica</i> (common buckthorn), an invasive shrub species found on the Argonne site.....	14
12	Northern Illinois habitat following prescribed burning.....	15
13	Argonne’s Advanced Protein Crystallization Facility landscaped with native flora. ....	16
14	Argonne Infrastructure Services grounds staff member operating a Bobcat® forestry device.....	18
15	Three-year management planning units. ....	19
E-1	Invasive Species Adaptive Management. ....	E-11

## Tables

1	Fiscal Timeframe Completion of Goals, Objectives, and Projects .....	17
E-1	Control of Invasive Plant Species at the Argonne Site.....	E-6

## 1.0 Purpose

Argonne National Laboratory is located on a 1,500-acre site comprised of a developed campus located within large tracts of undeveloped land (Figure 1). Approximately a third of the site consists of buildings, roads, parking lots, and support infrastructure.<sup>(1)</sup> The remaining portion is a complex of natural resources that include woodlands, prairie and grasslands, wetlands, and open space. Some of these areas are reserved for future development while others represent valuable ecosystems and potential protected habitat. Therefore, a series of natural resource management plans have been prepared for the management of the undeveloped campus within the context of mission need and overall site management requirements.<sup>(2,3)</sup>

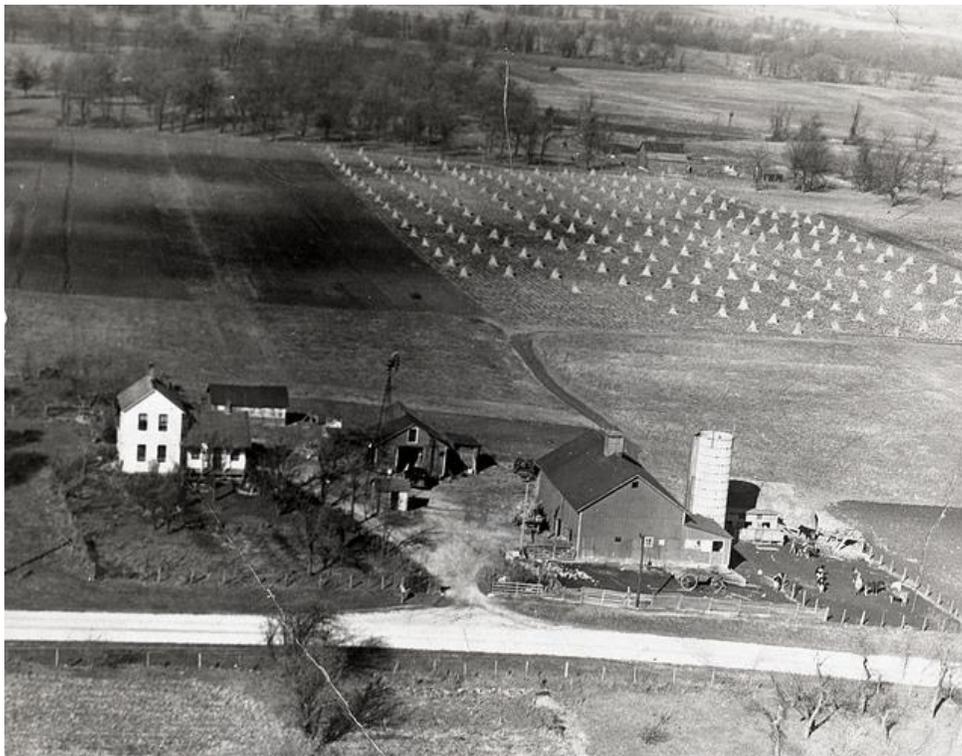


**FIGURE 1** Aerial view of the Argonne site today. Photo credit: Argonne National Laboratory.

This edition of the *Natural Resources Management Plan* is an action course for the next three fiscal years, 2018-2020. It builds on the progress of the three previous years — increasing floristic quality in habitats throughout the site, reducing the footprint of several invasive species populations, and introducing new techniques for contractors and grounds personnel, with a goal of increasing the overall size of on-site healthy ecosystems. In this next period, intensive mechanical control of invasive species will transition to more tailored tools such as controlled burning. Floristic quality assessment and species nomenclature have been improved for the Chicago region, and that will prompt a transitional period and effort to update field surveys and report development. Many lessons learned will refine our natural resource management efforts.

## 2.0 Background

In 1947, the land that became Argonne National Laboratory was in either (a) a natural state or (b) used for agriculture, as the Chicago region was just beginning its vast suburban development that occurred in the second half of the 20<sup>th</sup> century (Figure 2). Hence, habitats on the site were used for buffer space and screening as the communities that now surround it grew. In recent decades, the remaining natural areas (habitats) in urban regions and in the nation as well have become more valuable as their representation has diminished while their social and economic utility has increased significantly. During this same period, regulatory management of the environment has increased at every level of governance — federal, state, county, and municipal, and extending to private entities, as the relationship between humans and the natural world has increased in complexity.



**FIGURE 2** Aerial image of the Argonne site from 1939 showing farmland, woods, and open space. Photo credit: Argonne National Laboratory.

The U.S. Department of Energy (DOE) Order 430.1C Real Property Asset Management<sup>(4)</sup> is the primary directive for Argonne’s natural resource management. This Order instructs the agency to ensure that applicable requirements related and not limited to “natural resource preservation” are addressed.<sup>(5)</sup> Those requirements exist, however, in addition to the laboratory’s mission and to those actions that are more clearly defined in the order as real property asset management. It follows that the management of Argonne, as a federal government facility, must meet all

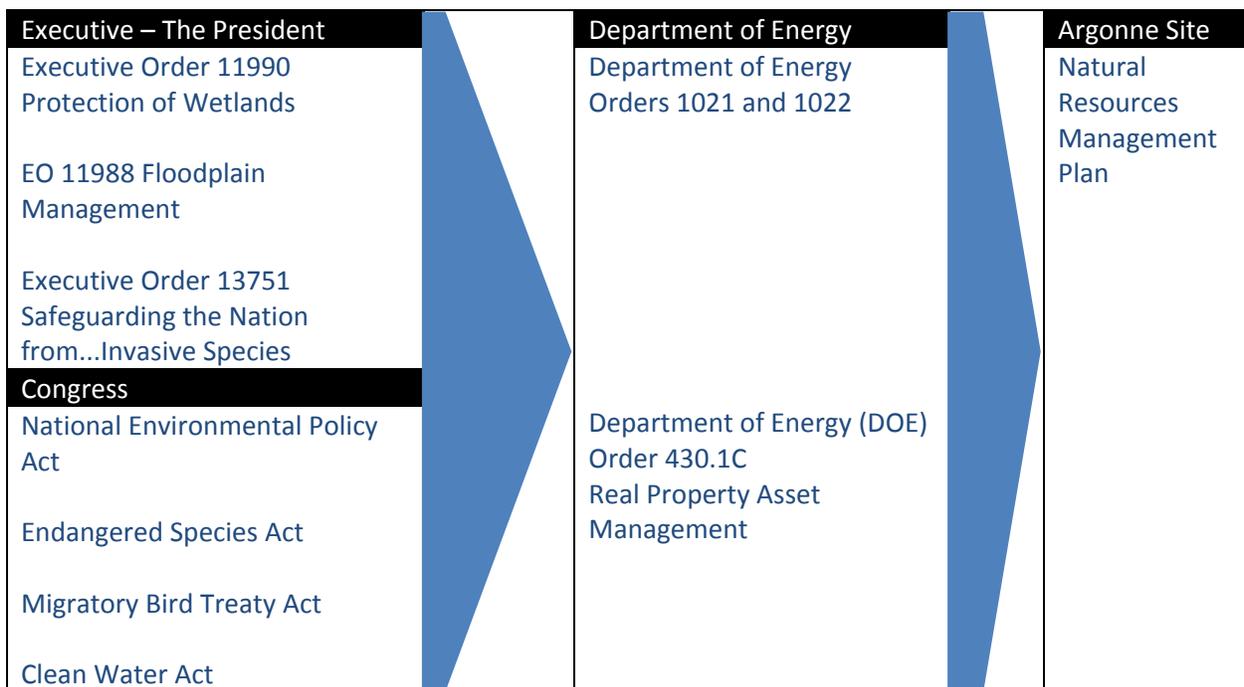
# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

regulatory requirements in addition to its direct scientific mission. The Argonne Site Office monitors the laboratory’s compliance with this and other directives and statutes.

An assessment of the site’s natural resources with other applicable federal statutes and requirements that affect those resources, reveal two general courses of action that are reflected in the goals of this management plan. The site’s natural resources are to be maintained and improved in quality and threats to those resources are to be reduced and controlled. For all federal agencies, two executive orders also provide executive direction:

1. Executive Order 11990, “Protection of Wetlands,” which directs agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands; and Title 10 of the Code of Federal Regulations, Parts 1021 and 1022, which is DOE’s implementation of this executive order; and
2. Executive Order 13751, “Safeguarding the Nation from the Impact of Invasive Species,” which directs federal agencies to control populations of invasive species and provide for the restoration of native species and habitats in affected ecosystems.

These two orders overlap in scope to cover all of the site’s natural resources. Next, Acts by Congress provide further direction for the management of natural resources (Figure 3).



**FIGURE 3 Relationships between Executive Orders, Congress, the U.S. Department of Energy, and the Argonne site.**

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Argonne’s natural resources include a threatened and endangered species. The Endangered Species Act 1973 (ESA) requires federal agencies to use their legal authorities to aid in the conservation of listed threatened or endangered (T&E) species. The Hine’s Emerald Dragonfly (HED) (Figure 4), a federal endangered species is, as of 2016, known from several locations on the Argonne site. Six other threatened and endangered species are in DuPage County: four plants, another insect, and one mammal species. At least two of those, the northern long-eared bat and the rusty-patch bumble bee, may visit and forage the site in the summer months. Argonne complies with the Endangered Species Act by protecting and enhancing the habitats of known T&E species present and conducting continuous monitoring of the site in search of the other species known from DuPage County. Discovery of threatened and endangered species is documented in the laboratory’s annual site survey report, and Argonne maintains an active dialogue with the US Fish and Wildlife Service regarding the status of T&E species on the Argonne site. In addition to the ESA, other statutes have requirements regarding natural resource management (Appendix C), such as the Clean Water Act, which regulates pollution, storm water discharges into waterways, and impacts to wetlands, and many of these statutes have implications for natural resource management.



**FIGURE 4** The Hine’s Emerald Dragonfly, a federally endangered species documented at several locations on the Argonne site. Photo credit: Paul Sparks/Shutterstock.com.

## 3.0 Define Land Use Areas

The 2016 Argonne Facilities and Infrastructure Strategic Investment Plan describes the overall management of the Argonne site to meet the scientific mission of the laboratory and fulfill the requirements of DOE. The plan classifies the site into the Primary Development, Environmental Corridor, Critical Habitat Buffer, and Environmental Monitoring (Figure 5). The Primary Development areas include existing programmatic mission areas, support services, and housing/amenities and areas identified as suitable for future development. The Environmental Corridor consists of sites that can accommodate future development for programmatic mission and support services, but also currently have significant natural resources. The Critical Habitat Buffer includes areas designated as open space and environmentally sensitive areas primarily within and adjacent to the 100-year floodplain.



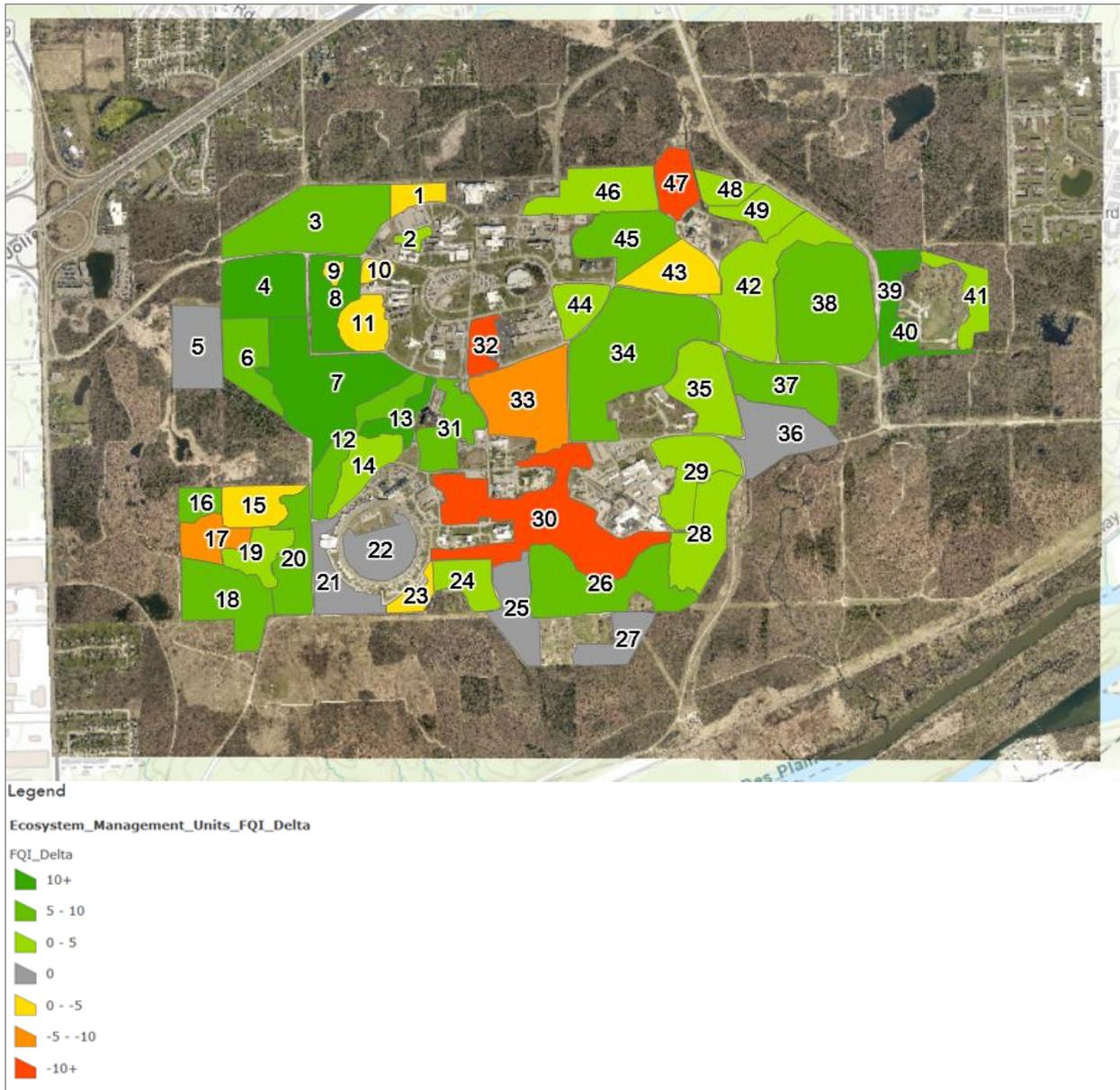
**FIGURE 5** Argonne campus plan.

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

The Critical Habitat Buffer and Environmental Corridor host the majority of Argonne’s natural resources. They comprise a number of different habitat types (Appendix A). Those resources are sub-divided into ecosystem management units (EMUs) to facilitate management (Appendix B). Roads, buildings or other constructed features often arbitrarily define ecosystem management units. EMUs typically include a predominant habitat type, but may contain more than one plant community. The boundaries of each unit can be adjusted in annual revisions of this management plan, based on changes in plant community characteristics or changes in management approach.

The depth of this analysis has facilitated progress in natural resource management objectives thus far. Populations of many invasive species have been reduced, habitats have improved in quality and biodiversity, and the site’s wetlands have been removed from regulatory compliance obligations. Those achievements create a new advanced baseline for more progress; however, invasive species populations and other threats are resilient, and any progress can easily be lost due to inconsistent focus or inaction (Figure 6).

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020



**FIGURE 6** GIS map showing Ecosystem Management Units, their respective numbers, and their improvement with management.

## 4.0 Natural Resources: Habitat Management Strategy

Argonne has generated a significant amount of information on the historic and current condition of the site's habitats through various surveys, research, and regulatory analyses. Annual vegetation assessments provide information on extant conditions, in particular, the status of T&E species and recommendations for habitat improvement. The wetlands have regulatory obligations that have resulted in a significant body of studies and reports (see References). There are other reports on birds, reptiles, and the greater surrounding Waterfall Glen Forest Preserve. These examinations of the site's natural resources reveal that the site retains a range of components from its former ecology. This information supports a management plan focusing on remnants of the pre-settlement plant community structure and species composition in the context of still-functioning abiotic processes such as hydrology, soil types, weather, and climate.

Natural habitats on the Argonne site formed over a considerable period of time and have been influenced by a variety of factors, particularly recent man-made alterations and influences. Those factors include soils, hydrology, landscape position, topography, slope and aspect, and the succession sequence of plant communities (See Appendix A, Plant Communities of the Argonne Site). The long-term goal of Argonne's natural resource management effort is to (a) reduce threats to habitat integrity, (b) due to significant site disturbance over more than 70 years, promote habitat dynamics of biotic and abiotic interactions, and (c) realize the maximum potential of the site's natural resources — biodiversity, ecosystem services, and green infrastructure. This goal fulfills all of the regulatory obligations for managing the Argonne site.

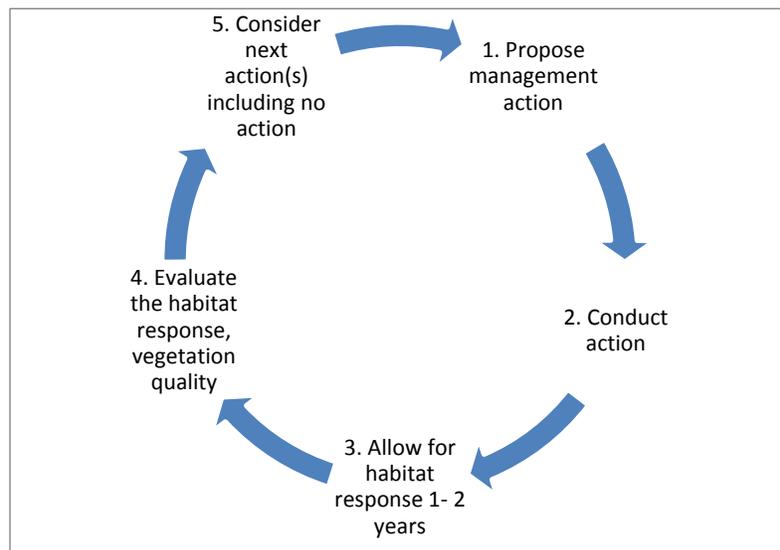
Ecologists determine the quality of a habitat by its vegetation community. That community forms the primary support for all other organisms, and there is a direct relationship between the quality of a plant community and the welfare of all other life. The standard assessment tools used to measure habitat integrity and change are the Floristic Quality Index (FQI) and Mean C values. These two inter-related values depict the quality of the vegetation and its integrity in response to disturbances. Successive assessments reveal how the vegetation quality responds to management actions. Vegetation in the mid-west region typically responds to management actions within three years; therefore, the site is divided into three management sections, and this assessment is conducted on one of those three divisions every year, in rotation. Usually, the FQI value will show an incremental increase over time in response to appropriate management actions. Ecosystem management units have current and historic FQI and Mean C values calculated from at least six years of consistent assessments. In-depth methodology and findings of this assessment are discussed annually and reported in the Argonne National Laboratory Ecology Survey.

In the Chicago region, sites of 10 or more acres that have both high FQIs and Mean C values are very rare, due to the region's vast urban development. This represents less than 0.5% of the region's land cover. Average FQI of sites in the Chicago region is 40; Argonne has several sites that exceed an FQI of 50. Optimum Mean C in the Chicago region is 5; Argonne sites have a Mean C of 4.0. In addition, several other locations approach those values in such a way that

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

those, too, will become high-quality natural areas with continued management. In order to realize the long-term goal to maximize values provided by the site's natural resources — biodiversity, ecosystem services, and green infrastructure, all FQI and Mean C values of individual EMUs should be rising with management, especially where those EMUs still possess elements of their historic ecology. See Floristic Quality Assessment, Revised, by Wilhelm and Masters<sup>(6)</sup> for an extensive discussion of the methodology of floristic assessments.

Argonne applies an integrated approach to managing the site's natural areas, determining priority with consideration to the condition of site resources against available funds, labor, and equipment. Hence, habitats with the highest quality ratings will receive management priority before lower-quality areas, so as to avoid backsliding to degraded quality. Where prioritization is required among communities with similar FQIs, those EMUs occurring within the Critical Habitat Buffer will receive the highest priority, followed by those in the Environmental Corridor, and then those in the developed areas (Figure 5). Effort in the secondary low-quality and developed areas generally is intended more to address invasive species or other concerns rather than to improve habitat; however, there may be exceptions where important natural resources can be preserved in the context of potential development (Figure 7). This approach is inherent in the goals and objectives stated below.



**FIGURE 7** Lessons learned process map.

Treatments are then selected that will improve habitat quality and reduce/control threats, mainly populations of invasive species. These may include native species augmentation, various methods of invasive species control that include prescribed fire, physical or chemical treatments, restoration of hydrology where appropriate, and deer management. Treatments are then assessed to determine both effectiveness and need for additional effort. Disturbed habitats typically require a continuous program of effort. Appendix E contains a more detailed Invasive Species Management Plan describing various control techniques employed by the laboratory.



**FIGURE 8** *Phragmites australis* (common reed), an invasive plant species found on the Argonne site. Photo credit: Svetlana Mahovskaya/Shutterstock.com.

The management strategy for wetlands receives particular attention from the Argonne Site Office. A permit is required for construction, dredging or filling, hydrology alteration, or other impacts to wetlands that may alter their condition as wetlands. These permits are issued by the Department of Energy and, where applicable by statute, by the United States Army Corps of Engineers. Much of the wetland effort managed under this plan is similar to work conducted in other habitats on the Argonne site — intended to control invasive species populations and improve vegetation quality.<sup>(7)</sup> Wetlands will also benefit from improvements to upland areas, in particular, where upland habitat improvements restore hydrology processes such that water tables contribute to the influx of standing water of wetlands, and the depth of the water table influences plant distribution and diversity (Figure 9).

Overall, wetland size in acres is relatively small, about 50 acres, in relation to the size of the Argonne site (1,500 acres); however, the habitat type is complex and has the potential to be among the most diverse on the property. Two wetlands are host to reproduction of the Hine’s Emerald Dragonfly, and others provide suitable habitat for reproduction and other behavior.



**FIGURE 9** Wetland on the Argonne site. Photo credit: Argonne National Laboratory.

## 5.0 Goals and Objectives

The goals of Argonne’s Land Management and Habitat restoration program (Table 1) present a broad vision of desired conditions on the Argonne site and direct the implementation of this plan for the next three years. Objectives more specifically describe management initiatives or strategies designed to achieve each goal. The goals and objectives are based on the management principles discussed in Section 4 and in Appendix A.

**GOAL 1.** Maintain high-quality remnant plant communities on the Argonne site (Figure 10).



**FIGURE 10** *Trillium grandiflorum* (great white trillium). Photo credit: Nikolay Kurzenko/Shutterstock.com.

**Objective 1.1.** Monitor natural areas to determine existing conditions, response to management actions, and resource threats.

**Project 1.1.1.** Survey one-third of the Argonne site natural areas each year, to include uplands and wetlands; update species lists for each land management tract; identify the presence of T&E species, document conditions, plant community, invasive species concerns and other threats.

**Project 1.1.2.** Develop, maintain, or revise management plans for individual ecosystem management units. Modify management plans based on previous annual survey results.

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

**Project 1.1.3.** Determine the status of threatened and endangered species at Argonne by consulting with the U.S. Fish and Wildlife Service (USFWS).

**Objective 1.2.** Focus management actions in previously managed sites, wetlands, and threatened and endangered species habitat.

**Project 1.2.1.** Conduct restoration activities (e.g., burns, cutting) on previously treated areas, based on three-year cyclic management plan schedules.

**Project 1.2.2.** Incorporate non-compliance wetlands into this Natural Resources Management Plan framework from previous division management. The laboratory's Infrastructure Services Natural Resources Manager will coordinate program history and data from the appropriate personnel, including appropriate transfer of budget authority.

**Project 1.2.3.** Conduct habitat restoration techniques with protocols to avoid harm to threatened and endangered species.

**Sub-Project 1.2.3.1.** Conduct improvement effort in Hine's Emerald Dragonfly habitat following Argonne's Inter-Service Hine's Emerald Dragonfly Technical Guidance from USFWS. See Appendix B, EMUs 03 and 26.

**Sub-Project 1.2.3.2.** Conduct habitat improvement efforts with situational awareness of potential T & E species presence See ASO-CX-344 Habitat Maintenance Activities.

**Project 1.2.4.** Preserve site-wide oak tree health.

**Sub-Project 1.2.4.1.** Inspect and record oak trees displaying signs of premature decline.

**Sub-Project 1.2.4.2.** Treat oak trees in decline with plant health care treatments.

**Sub-Project 1.2.4.3.** Plant oak trees in the landscape of developed areas to maintain oak presence with at least one oak tree planted for each oak tree death.

**Sub-Project 1.2.4.4.** Install mulch beds around oak trees and groups of oak trees.

**Sub-Project 1.2.4.5.** Plant mulch bed with selected ground cover of compatible species: native species found in local oak savannah ecosystems.

**Objective 1.3.** Expand restoration activities into selected remnant plant communities from high quality areas to those that are lower quality.

**Project 1.3.1.** Develop a restoration plan for selected management unit(s) and initiate activities.

**Sub-Project 1.3.1.1.** Remove 30 to 50 acres of invasive shrub infestation (e.g., buckthorn, honeysuckle, etc.) in wooded ecosystem management units annually with mechanical clearing.

**Sub-Project 1.3.1.2.** Control cool-season grasses in prairie management areas to eliminate competition with native plants.

**GOAL 2.** Conduct Invasive Species Control/Integrated Pest Management Plan (Appendix E) for identified populations throughout the site (Figure 11).



**FIGURE 11** *Rhamnus cathartica* (common buckthorn), an invasive shrub species found on the Argonne site. Photo credit: Nelly B/Shutterstock.com.

**Objective 2.1.** Identify and control new and/or existing invasive plant species.

**Project 2.1.1.** Identify herbaceous invasive species with localized populations based on results of annual site surveys.

**Project 2.1.2.** Implement invasive tree/shrub/vine control actions per the Invasive Species Control Plan

**Objective 2.2.** Detect, identify and control potentially harmful insect populations.

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

**GOAL 3.** Re-establish natural plant communities in the critical habitat buffer or environmental corridor (Figure 12).



**FIGURE 12** Northern Illinois habitat following prescribed burning.  
Photo credit: ESB Basic/Shutterstock.com.

**Objective 3.1.** Identify/select appropriate locations to re-establish native plant communities.

**Project 3.1.1.** Identify areas currently lacking native plant communities and develop appropriate management strategy. Priority will be based on (1) potential spread or host of invasive species, followed by (2) connectivity and defragmentation of adjacent habitats, and (3) visual enhancement.

**Objective 3.2.** Convert non-native plant communities to native plant communities.

**Project 3.2.1.** Increase prairie acreage by three acres annually.

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

**GOAL 4.** Incorporate native species into landscaped areas of the site where such will meet a specified federal requirement (Figure 13).



**FIGURE 13** Argonne’s Advanced Protein Crystallization Facility landscaped with native flora. Photo credit: Argonne National Laboratory.

**Objective 4.1.** Identify locations for sustainable landscaping in capital construction projects consistent with guidance found in Executive Order 13693.

**Project 4.1.1.** Prepare and distribute to projects Site Landscape Plant List (SLPL) for landscaping of capital construction projects. Landscape design can include non-native plants; however, native plant species must be utilized to blend designs into the natural landscape. Selection of non-native species will exclude all invasive species and those species that can hybridize with other local species. The SLPL can change according to project-specific requirements. See Appendix D for SLPL.

**Project 4.1.2.** Provide guidance to Infrastructure Services and the Project Management Office design contractors, grounds managers, and other project management staff to ensure a smooth transition between project concept development and final plan, to ensure that longevity and sustainability requirements are matched to long-term maintenance capability.

**Objective 4.2.** Provide design guidance to contractor and internal staff (grounds personnel) in identification of species used in sustainable landscaping and maintenance objectives.

**Project 4.2.1.** Respond to grounds personnel needs for Goal 4 guidance as represented in the Facilities Design Guide 2018.

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

**TABLE 1 Fiscal Timeframe Completion of Goals, Objectives, and Projects**

Goals, Objectives, and Projects	Abbreviated Descriptions	Fiscal Quarter			
		1	2	3	4
<b>GOAL 1</b>	Maintain existing remnant plant communities on the Argonne site				
Objective 1.1	Monitor natural areas				
Project 1.1.1	Survey one-third of the Argonne site natural areas				
Project 1.1.2	Develop, maintain, or revise management plans				
Project 1.1.3	Determine the status of T&E Species and consult USFWS				
Objective 1.2	Focus MGMT actions in managed sites, wetlands, T&E habitat				
Project 1.2.1	Conduct restoration activities on previously treated areas				
Project 1.2.2	Incorporate non-compliance wetlands into Land Management/Habitat Restoration (LMHR) program				
Project 1.2.3	Conduct habitat restoration techniques avoiding harm to T&E species				
Sub-Project 1.2.3.1	Conduct Improvement effort in Hine’s Emerald Dragonfly habitat				
Sub-Project 1.2.3.2	Conduct habitat improvement with awareness of T&E species				
Project 1.2.4	Preserve site-wide oak tree health.				
Sub-Project 1.2.4.1	Inspect and record oak trees displaying signs of premature decline.				
Sub-Project 1.2.4.2	Treat oak trees in decline with plant health care treatments.				
Sub-Project 1.2.4.3	Plant oak trees in the developed areas to maintain oak presence.				
Sub-Project 1.2.4.4	Install mulch beds around oak trees and groups of oak trees.				
Sub-Project 1.2.4.5	Plant mulch beds with selected native species found in oak woods.				
Objective 1.3	Expand restoration activities into selected remnant habitats				
Project 1.3.1	Develop and engage restoration plans for management units				
Sub-Project 1.3.1.1	Remove 30-50 acres of invasive shrubs in ecosystem mgmt units				
Sub-Project 1.3.1.2	Control cool-season grasses in prairie management areas				
<b>GOAL 2</b>	Conduct Invasive Species Control/Integrated Pest Management				
Objective 2.1	Identify and control new and/or existing invasive plant species.				
Project 2.1.1	Identify herbaceous invasive species with localized populations				
Project 2.1.2	Implement invasive tree/shrub/vine control actions				
Objective 2.2	Identify and control harmful insect populations.				
<b>GOAL 3</b>	Re-establish natural plant communities				
Objective 3.1	Identify locations to re-establish native plant communities.				
Project 3.1.1	Identify areas and strategy for new native plant communities				
Objective 3.2	Convert non-native plant communities to native.				
Project 3.2.1	Increase prairie acreage by three acres annually.				
<b>GOAL 4</b>	Incorporate native species into landscaped areas of the site				
Objective 4.1	Identify locations for sustainable landscaping in capital projects				
Project 4.1.1	Prepare and distribute to projects Site Landscape Plant List				
Project 4.1.2	Provide landscape design guidance to IS-Infrastructure				
Objective 4.2	Provide landscape guidance to contractors and Grounds personnel				
Project 4.2.1	Advise project needs of Goal 4 for the Facilities Design Guide 2018				

## 6.0 Roles and Responsibilities

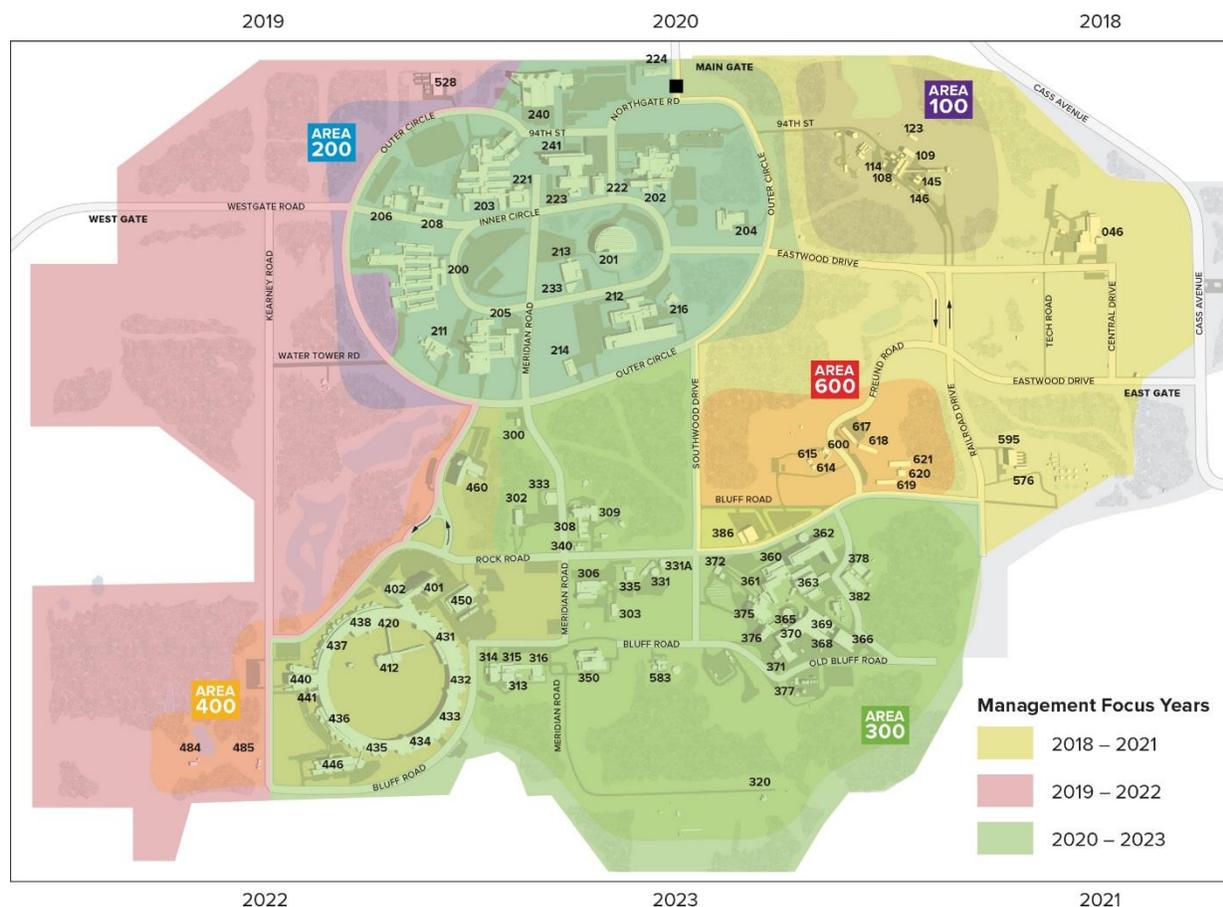
The Argonne Site Office has overall responsibility for land management at Argonne National Laboratory. The laboratory's Infrastructure Services Division (IS) is responsible for planning and implementing natural management that comply with all appropriate directives and laws. IS's Sustainability & Environmental Program group conducts the necessary planning, budgeting, and coordination with input from the IS Natural Resources Manager and subject matter experts from the laboratory's Environmental Sciences (EVS) Division. The Natural Resources Manager supervises the implementation of all site work. IS-Grounds personnel and/or contractors perform land management and habitat restoration work (Figure 14). Finally, the Natural Resources Manager determine's annual site work project priorities with their costs against an annual budget allocation. The latter is determined during fiscal year budget development with foresight of future needs based on the objectives if this plan and habitat conditions.



**FIGURE 14** Argonne Infrastructure Services grounds staff member operating a Bobcat® forestry device. Photo credit: Argonne National Laboratory.

## 7.0 Implementation and Monitoring

This plan divides the lab into three generally equal sections for focusing annual management resources and to implement an adaptive management procedure. Site work is annually conducted by contractors or Argonne grounds personnel at the direction of the laboratory’s Natural Resources Manager. After two years, actions conducted are evaluated using floristic assessments of the predominant vegetation and changes that have occurred. A report is then prepared with observations and recommendations for the next management cycle. The reports, historically titled “Site Ecology Reports,” contain recommendations that are then used in subsequent years for revising or updating management plans. In this manner, in any given year at least a third of the site receives management action, a third is allowed to respond to the previous year’s action, and a third is being assessed for actions performed two years previous. This process rotates to one of the three areas every year (Figure 15).



**FIGURE 15** Three-year management planning units.

## 8.0 References

**Note:** Argonne publications referenced below will be available through the laboratory’s Natural Resources Program website at [www.anl.gov/sustainability/natural-resources-program](http://www.anl.gov/sustainability/natural-resources-program).

1. “Facility and Infrastructure Strategic Investment Plan,” Argonne National Laboratory, Lemont, IL (2016).
2. “Natural Resources Management Plan (NRMP) 2015–2017,” Argonne National Laboratory, Lemont, IL (2015).
3. “Natural Resources Management Plan (NRMP) 2012–2014,” Argonne National Laboratory, Lemont, IL (2012).
4. DOE Order 430.1C, “Real Property Asset Management,” Section 4 Requirements. Available at <https://www.directives.doe.gov/news/0430.1C-new>.
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6. Wilhelm, G., and L. Masters, “Floristic Quality Assessment, Revised,” Conservation Research Institute, Lombard, IL (1995). Available at <http://www.conservationresearchinstitute.org/assets/chicagoareafqa.pdf>.
7. “Argonne National Laboratory Wetland Management Implementation Plan,” ANL/EQO/Wetlands-2007/1. Argonne National Laboratory, Lemont, IL (2007).

## Appendix A: Plant Communities of the Argonne Site

The 1,500-acre Argonne site includes approximately 1,000 undeveloped areas, many of which support native plant communities. Prior to European settlement of the region, the types of plant communities present on what is now the Argonne site were primarily open savanna/prairie and savanna, with smaller areas of woodland and forest,<sup>(1)</sup> on silt loam and silty clay loam soils.<sup>(2)</sup> All of these communities included at least some trees, primarily oaks (*Quercus spp.*). Prior to federal acquisition of the land in 1946, most of the Argonne site was in agricultural use, both for crop production and livestock grazing. Fire suppression began with settlement around 1840. During this time, the remnant natural areas were likely used for grazing as well as sources of timber.

Many natural areas were lost as trees were cut and fields were plowed. Populations of white-tailed deer (*Odocoileus virginianus*) increased considerably following the establishment of Argonne, with subsequent effects on plant communities by selective herbivory. Argonne construction activities and other land disturbances began in the late 1940s and have generally been concentrated in several areas scattered throughout the site. As a result of past land uses, natural areas on the site are considerably fragmented and disturbed, although there are still a number of relatively large undisturbed areas.

Plant communities of the Argonne site were surveyed and mapped in 1998 and have been surveyed consistently since 2011. The community maps have been entered into the Argonne Geographic Information System (GIS) and the dominant species of each plant community recorded in a database integrated with the GIS. The survey was repeated in 2003, including the diameters at breast height (dbh) of selected trees, and the GIS files were updated. Comprehensive species lists for many of the plant communities have been developed to include all known species in each community. For these communities, a Floristic Quality Index has been calculated using the protocol described in Swink and Wilhelm (1994).<sup>(3)</sup> This index allows for the identification of high-quality remnant natural areas — it also provides a measure of the overall quality or degradation of Argonne plant communities. All of the plant communities on the Argonne site have been degraded to varying extents by factors such as fire suppression, former grazing of livestock, hydrologic alterations, establishment of invasive species, herbivory by deer, and construction. However, a number of high-quality natural communities still occur on the site. Plant communities, which are classified based on the Chicago Wilderness community classification system, are described below.

**Woodlands** on the Argonne site include a wide range of habitat types, successional stages, and floristic quality. These remnant natural communities are the most common on the site. Canopy openness of mature native trees ranges from approximately 50% to nearly 100%, with dominant species consisting of white oak (*Quercus alba*), black oak (*Q. velutina*), bur oak (*Q. macrocarpa*), and red oak (*Q. rubra*). A large number of these trees exceed 80 cm dbh and 150 years in age. The larger trees (over 100 cm dbh) likely predate European settlement of the area. A variety of secondary species, such as shagbark hickory (*Carya ovata*) and black cherry (*Prunus serotina*), also commonly occur in these woodlands. Several woodlands support highly

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

conservative species (species that are found most often in high-quality, undisturbed native habitats) such as large-flowered trillium (*Trillium grandiflorum*) and wood sandwort (*Arenaria lateriflora*). Because of the presence of many younger fire-intolerant native trees, such as black cherry, the canopies of these woodlands are closed (100%). Non-native invasive species, such as common buckthorn (*Rhamnus cathartica*), a small- to medium-sized tree, and shrub honeysuckle (*Lonicera spp.*), have become established in all of the woodlands on the Argonne site, in many cases forming a dense thicket with few native herbaceous species. Soil erosion sometimes occurs beneath these thickets. Other invasive species often present are oriental bittersweet (*Celastrus orbiculatus*) and garlic mustard (*Alliaria petiolata*). Reproduction and recruitment of the canopy oak species seldom occur in woodland communities of the site. Infestations of gypsy moths (*Lymantria dispar*) have resulted in temporary defoliation of canopy and understory trees. The woodland communities on the Argonne site include dry-mesic silt loam woodland, mesic silt loam woodland, and wet-mesic silt loam woodland. Some woodland communities contain vernal pools or basin marsh communities.

Savanna communities are also common on the Argonne site. The dominant trees of these remnant natural communities are generally bur oak, white oak, or black oak, or some combination of these species. The canopy of mature trees averages 10% to 50%, with many pre-settlement trees present. These communities tend to have greater average tree diameters than the woodlands onsite, but support fewer highly conservative species. However, a large number of younger trees, particularly of Hill's oak (*Quercus ellipsoidalis*), now creates a nearly closed canopy. As in the woodland communities, invasive species have become established in all of the savanna communities on the Argonne site. Soil erosion occurs in some areas where invasive species have formed dense thickets. Much of Argonne's 200 Area includes remnant savanna communities in which the understory has been replaced with turf grasses. The reproduction and recruitment of the canopy oak species are generally absent from the savanna communities. At times, infestations of gypsy moths have resulted in the temporary defoliation of canopy and understory trees in some savannas on the Argonne site. The savanna communities on the Argonne site include dry-mesic silt loam savanna, mesic silt loam savanna, and wet-mesic silt loam savanna. Some savanna communities contain vernal pools or basin marsh communities.

Stands of jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), or red pine (*Pinus resinosa*) were planted in the 1950s to provide an acceptable plant cover on previously cultivated fields that had become weedy following abandonment. Although these pine species are native to the Chicago region, they are not known to be part of DuPage County natural communities, and do not constitute a native plant community. Other plantations of hardwoods were also planted in the same period. Patches of walnut (*Juglans nigra*), sweet gum (*Liquidambar styraciflua*), and ash (*Fraxinus sp.*), among others, remain and have demonstrated succession or have become slightly degraded. These sites can be regarded as mid-period successional communities and managed toward oak/hickory woodland or savannah; however, most have an understory of unassociated woody species, particularly of invasive buckthorn and honeysuckle.

A number of areas are classified as **unassociated vegetation**. These areas support a variety of weedy native and non-native trees, such as box elder (*Acer negundo*), green ash (*Fraxinus*

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

*pennsylvanica subintegerrima*), black cherry, common buckthorn, and black locust (*Robinia pseudoacacia*). These communities have generally become established on former agricultural fields and do not progressively develop into a successive community where dominant species (often long-lived, as in trees) support highly diverse and regular assemblages of plant species. Agricultural field soils are highly disturbed and only remotely resemble the parent soil. That soil was formed and matured by the influence of successive plant communities over time; hence, opportunist weedy species are more capable of invading and perpetuating populations in disturbed field soils over the same period of time that successional plant communities would occur. Management can direct successional processes toward native prairie or woodland establishment with restoration best-management practices.

Dominant **grassland** communities on the site generally have an invasive shrub component and are classified as unassociated grasses and forbs. These communities have become established on former agricultural fields. Most of the grasslands are primarily composed of non-native, cool-season grasses, such as orchard grass (*Dactylis glomerata*), tall fescue (*Festuca elatior*), and Hungarian brome (*Bromus inermis*), with occasional native forbs, such as wild bergamot. These communities also include the woody invasive species common buckthorn and honeysuckles, as well as herbaceous non-native invasive species such as crown vetch, field thistle (*Cirsium arvense*), and cut-leaved teasel (*Dipsacus laciniatus*). In many areas, these latter species are the dominant species, with few other species present.

There are a few areas that could be considered prairie communities on the Argonne site, but these lack a complex of highly conservative species. The native species present tend to be forbs, such as Deam's rosinweed (*Silphium integrifolium deamii*), prairie dock (*Silphium terebinthinaceum*), wild bergamot (*Monarda fistulosa*), and yellow coneflower (*Ratibida pinnata*). However, Indian grass (*Sorghastrum nutans*) and big bluestem (*Andropogon gerardii*) occur in several areas. Non-native species are common in these communities, and several, such as crown vetch (*Coronilla varia*), are invasive. The largest prairie community on the Argonne site, located in southwestern portion of the site, is approximately 10 acres in size. However, most or all of this community was possibly planted since the establishment of Argonne. The prairie communities on the Argonne site include dry-mesic silt loam prairie, mesic silt loam prairie, wet-mesic silt loam prairie, and wet silt loam prairie.

**Wetlands** are the habitat with the most regulation both here and in the nation, and have physiographic connections to all other habitats. Particular focus is directed to wetlands and adjacent uplands to meet or preserve natural assets that meet or may serve regulatory requirements.

Wetlands on the Argonne site range from basin marsh and wet prairie to vernal pools. These wetlands represent a variety of types, including (1) floodplain or riparian wetlands; (2) forested wetlands; and (3) marshes, dominated by cattails, grasses, sedges, and rushes. Several high quality, relatively undisturbed wetlands support unusual plant species or high species diversity. Some of the wetlands are of relatively recent origin and have been formed as a result of human activities. Many of these have degraded plant communities with relatively weedy species and

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

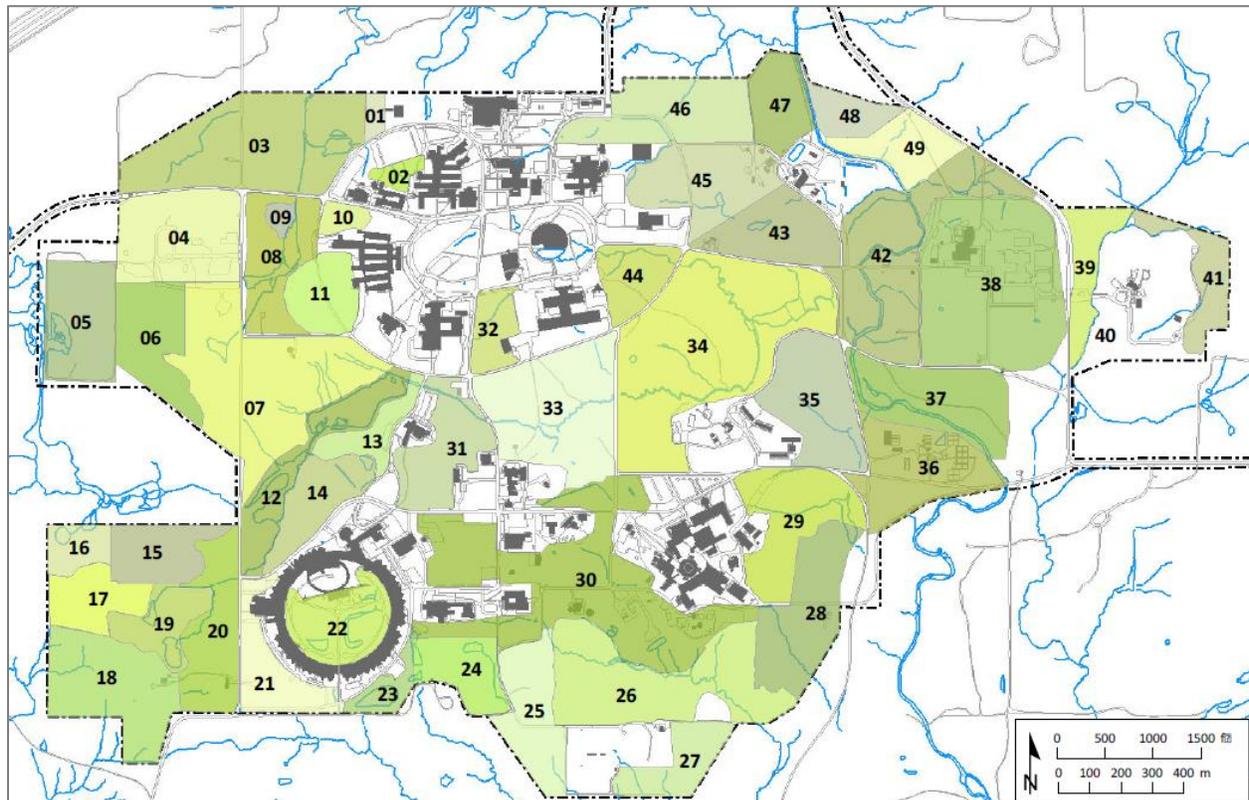
low species diversity. These are dominated by cattail (*Typha spp.*), common reed (*Phragmites australis*), or reed canary grass (*Phalaris arundinacea*). Purple loosestrife (*Lythrum salicaria*) is also common in several wetlands. Disturbance, pollution, alteration of natural hydrologic regimes, and increased sedimentation generally favor the colonization and continued spread of these invasive species.

Argonne completed a site-wide wetland delineation in 1993. All wetlands present on site were identified and mapped following the 1987 Army Corps of Engineers Wetlands Delineation Manual. The delineation map shows the extent of all wetlands present at Argonne. Thirty-five individual wetland areas were identified; their total area is approximately 20 ha (50 acres). A compensatory site, Wetland R, was created for wetland losses caused by the building of the Advanced Photon Source. In 2011, the Corps of Engineers stated this mitigation wetland was successfully established and requested that continuous monitoring be conducted. Argonne has also restored and improved several acres of high-quality wetland in the 400 Area (Wetland 302) by disabling a drainage tile network installed when the land was a farm.

### References:

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## Appendix B: Ecosystem Management Units



**EMU 01:** This unit includes mesic savanna, in two small individual stands. Construction of the chilled water facility has eliminated approximately half of the western stand. The dominant tree species of the canopy in both stands are bur oak (*Quercus macrocarpa*) and white oak (*Q. alba*). This unit includes black walnut (*Juglans nigra*) trees planted by Argonne in 1954. The west boundary of this unit is formed by a hedgerow of large osage orange (*Maclura pomifera*) trees. The savanna communities contain several species with a C=8: downy green sedge (*Carex swanii*), narrow-leaved oval sedge (*Carex tenera*), flowering dogwood (*Cornus florida*), flat-stemmed spike rush (*Eleocharis compressa*), and spinulose shield fern (*Dryopteris spinulosa*). Redbud (*Cercis canadensis*), present in this unit, has a C=10. Common stiff sedge (*Carex tetanica*), which has a C=9, occurred in the western stand in the area of the chilled water facility. A basin marsh is located between the two oak stands. This wetland is a naturally occurring wetland that is drained by a culvert under the Argonne boundary fence. Although this wetland is dominated by narrow-leaved cattail (*Typha angustifolia*), it supports a high diversity of native plant species. The floristic quality of this unit is moderate.

**EMU 02:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy are bur oak and white oak. Two small wetland areas, supported by building drainage, are dominated by narrow-leaved cattail. An area of unassociated grasses and forbs in the western portion of this unit is composed nearly entirely of non-native species. The savanna had been

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

regularly mowed until 2005. A population of buckthorn became established and was cut once, in 2015. The floristic quality of this unit is low to moderate.

**EMU 03:** This unit primarily consists of pine plantations, including red pine (*P. resinosa*), white pine (*P. strobus*), and jack pine (*P. banksiana*). Some areas that had been planted with jack pine, which have been in decline in recent years, are now considered unassociated woody growth, with black cherry (*Prunus serotina*) composing most of the tree canopy. Conservative species observed in this unit include mockernut hickory (*Carya tomentosa*), C=10; rattlesnake master (*Eryngium yuccifolium*) and marsh blue grass (*Poa palustris*), both C=9; and lady fern (*Athyrium filix-femina*), downy green sedge, spinulose shield fern, sensitive fern (*Onoclea sensibilis*), and chinquapin oak (*Quercus muhlenbergii*), all C=8. A large wetland that is primarily a basin marsh is located within this unit and is dominated by narrow-leaved cattail, and non-natives reed canary grass (*Phalaris arundinacea*) and common reed (*Phragmites australis*). Larvae of the Hine's Emerald Dragonfly, a federally and state-listed endangered species, was discovered in this wetland. The northern portion of this wetland includes a segment of Wards Creek, a tributary of Sawmill Creek, however, much of the channel within this wetland had been excavated during development of the Argonne site to convey surface water from the 800 and 200 Areas. This wetland is drained by a culvert under the Argonne boundary fence. The floristic quality of this unit is low to moderate.

**EMU 04:** This unit is comprised of the Argonne 800 Area, which had previously contained numerous temporary buildings and storage areas. Conservative species observed in this unit include *Pinus resinosa* (C=10), sweet grass (*Hierochloa odorata*) (C=9), and narrow-leaved oval sedge (C=8). The entire unit has been significantly disturbed and supports a mosaic of upland and wetland plant communities. Wetland development is associated with compacted soils, excavations, and altered drainage patterns. Although the dominant species in these communities are non-native, a variety of disturbance-tolerant native species are present. The floristic quality of this unit is low to moderate.

**EMU 05:** This unit includes the Argonne landfill area. The landfill cover was completed in 1993 and supports a herbaceous community of mostly non-native grasses. A basin marsh is located along the western boundary fence line and is contiguous with a large marsh in Waterfall Glen Forest Preserve. Dominant species in the marsh are common reed, narrow-leaved cattail, and non-natives reed canary grass and common reed. A small remnant of a jack pine plantation is located in the southwest corner of this unit and includes deciduous woody species, primarily non-natives. The floristic quality of this unit is low.

**EMU 06:** This unit primarily consists of white pine and jack pine plantations. Much of the area that had been planted with jack pine is now becoming dominated by deciduous woody species, primarily non-natives. Sweetgum (*Liquidambar styraciflua*), planted by Argonne in 1954, occurs in the northern section of this unit. Conservative species observed in this unit include lady fern, downy green sedge, narrow-leaved oval sedge, spinulose shield fern, and sensitive fern, all C=8. A basin marsh is located within this unit and supports a wide variety of mostly native species. The northern portion of the wetland includes a drainage ditch, conveying water to a culvert under

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Kearney Road. The northernmost portion of this unit consists of an area of unassociated grasses and forbs composed nearly entirely of non-native species. The floristic quality of this unit is low to moderate.

**EMU 07:** This unit primarily consists of unassociated woody growth. The dominant tree species vary throughout the unit and include the native species box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica subintegerrima*), and eastern cottonwood (*Populus deltoides*). Green ash was planted by Argonne in this location in 1954. Conservative species observed in this unit include great bladderwort (*Utricularia vulgaris*) (C=9), and narrow-leaved oval sedge, pale purple coneflower (*Echinacea pallida*), false pennyroyal (*Isanthus brachiatus*), sensitive fern, and white water crowfoot (*Ranunculus longirostris*), all C=8. Portions of this unit had been disturbed in the past by facility construction and demolition. Small degraded remnants of mesic prairie occur in this unit, primarily along Kearney Road and near the intersection of Watertower and Outer Circle Roads. Numerous small wetlands occur within this unit, primarily supporting native sedges (*Carex spp.*) and bulrush (*Scirpus spp.*). In recent years, a significant wet prairie community has developed west of Kearney Road, likely the result of drain tile failure. A basin marsh with a variety of native sedges and forbs is located in the western section of the unit. A wetland in the eastern portion of the unit is supported by drainage from nearby watertowers and dominated by narrow-leaved cattail and common cattail (*Typha latifolia*). The floristic quality of this unit is low to moderate.

**EMU 08:** This unit primarily consists of unassociated grasses and forbs, composed nearly entirely of non-native species, with non-native shrubs predominating over much of the area. Marsh blue grass (*Poa palustris*) (C=9) occurs in this unit. Areas of this unit had been disturbed in the past by facility construction and demolition. This unit includes a basin marsh. A portion of this wetland is naturally occurring, however, much of the wetland had been excavated during development of the Argonne site to convey surface water from the 800 Area. Dominant species include narrowleaved cattail, sandbar willow (*Salix interior*), and common reed. The floristic quality of this unit is low to moderate.

**EMU 09:** This unit consists of dry-mesic savanna. The dominant tree species of the canopy is black oak (*Quercus velutina*). Green ash and black walnut planted in this location by Argonne in 1954 occur in this unit. A variety of native herbaceous species is present under the oak canopy, but sparse in coverage. A drainage ditch along the eastern margin of the unit conveys surface water north from the 800 Area and supports a wetland community of shrubs and herbaceous species. The floristic quality of this unit is low to moderate.

**EMU 10:** This unit consists of dry-mesic savanna. The dominant tree species of the canopy are black oak and bur oak. This savanna is isolated, being surrounded by mowed lawns. A wide variety of native shrubs and herbaceous species are present. The floristic quality of this unit is moderate.

**EMU 11:** This unit includes mesic savanna, in two stands separated by Outer Circle Road. The dominant tree species of the canopy are bur oak and white oak. This unit includes black walnut

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

trees planted by Argonne in 1954. The savanna community contains two species with a C=8: narrow-leaved oval sedge (*Carex tenera*) and large-flowered trillium (*Trillium grandiflorum*). A variety of native shrubs and herbaceous species are present, with species diversity particularly high in the eastern section of the unit. The floristic quality of this unit is high.

**EMU 12:** This unit consists of two streamside marsh wetlands connected by a narrow channel. These wetlands are associated with the floodplain of the lower branch of Freund Brook. Agricultural drainage tiles were removed from the southern wetland in 2001 to increase the wetland area. Conservative species observed in this unit include *Eryngium yuccifolium* (C=9), *Poa palustris* (C=9), grass-leaved arrowhead (*Sagittaria graminea*) (C=9), bottlebrush sedge (*Carex lurida*) (C=8), stiff bedstraw (*Galium tinctorium*) (C=8), and arum-leaved arrowhead (*Sagittaria cuneata*) (C=8). The northern wetland includes extensive stands of common reed, while the southern wetland includes large areas of narrow-leaved cattail. A beaver dam at the northern end of this unit has raised water levels considerably in recent years. The floristic quality of this unit is moderate.

**EMU 13:** This unit primarily consists of unassociated woody growth, composed of woody native and non-native species. Canopy species are primarily eastern cottonwood (*Populus deltoides*) and non-native black locust (*Robinia pseudoacacia*). Areas of this unit had been disturbed in the past by facility construction. This unit includes sycamore (*Platanus occidentalis*) trees planted by Argonne in 1954. Conservative species observed in this unit include sycamore (*Platanus occidentalis*) (C=9), wood sandwort (*Arenaria lateriflora*) (C=8), and *Carex tenera* (C=8). A small wetland community in the northern part of the unit has expanded in recent years due to the presence of a beaver dam in unit 12 and is dominated by narrow-leaf cattail. The floristic quality of this unit is low to moderate.

**EMU 14:** This unit consists of mesic savanna. The dominant tree species of the canopy are bur oak and white oak. The savanna community contains one species with a C=8: spinulose shield fern. A canal, excavated during the early development of the Argonne site, is located in the northeast part of the unit and contains a gabion dam to hold surface water runoff from nearby parking lots. The canal is a remnant of a larger wetland, which was mostly filled in during construction of the Advanced Photon Source (APS). A small wetland has developed in the northeast corner of the unit as a result of altered surface drainage patterns during APS construction. The floristic quality of this unit is moderate to high.

**EMU 15:** This unit primarily consists of a jack pine plantation. Much of the area that had been planted with jack pine, which have been in decline in recent years, is now becoming dominated by deciduous woody species, primarily non-natives. Conservative species observed in this unit include lady fern, spinulose shield fern, floating manna grass (*Glyceria septentrionalis*), and sensitive fern, all C=8, and false aster (*Boltonia latisquama recognita*), C=9. The west and south boundaries of this unit are formed by a hedgerow of large osage orange trees. The floristic quality of this unit is low to moderate.

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

**EMU 16:** This unit consists primarily of mesic savanna. The dominant tree species of the canopy are bur oak and white oak, with black oak and red oak also present. The savanna community contains several species with a C=8: spinulose shield fern, narrow-leaved oval sedge, downy green sedge, and lady fern (*Athyrium filix-femina*). This unit includes a basin marsh and a streamside marsh associated with the floodplain of the South Branch of Freund Brook. The basin marsh is dominated by common bur reed (*Sparganium eurycarpum*) while the streamside marsh is dominated by common reed. Grass-leaved arrowhead (*Sagittaria graminea*), C=9, and floating manna grass (*Glyceria septentrionalis*), C=8, occur in the basin marsh. The floristic quality of this unit is moderate, trending to high.

**EMU 17:** This unit primarily consists of unassociated woody growth, composed of woody native and non-native species. Canopy species in this low-lying area are primarily box elder (*Acer negundo*) and green ash. An extensive network of drain tiles was discovered in this unit, discharging to the west in Waterfall Glen. Downy green sedge and spinulose shield fern, C=8, and woodland blue grass (*Poa sylvestris*) C=10, occur in this unit. The floristic quality of this unit is low to moderate.

**EMU 18:** This unit consists primarily of mesic prairie dominated by big bluestem (*Andropogon gerardii*) and Indian grass (*Sorghastrum nutans*). It is likely that much of this prairie was planted by Argonne. Narrow-leaved oval sedge, downy green sedge, prairie blazing star (*Liatrix pycnostachya*), side oats grama (*Bouteloua curtipendula*), bottle gentian (*Gentiana andrewsii*), pale purple coneflower, flat-stemmed spike rush (*Eleocharis compressa*), and wild quinine (*Parthenium integrifolium*), all C=8; rattlesnake master (*Eryngium yuccifolium*), white prairie clover (*Petalostemum candidum*), sweet black-eyed susan (*Rudbeckia subtomentosa*), and purple prairie clover (*Petalostemum purpureum*), all C=9; and prairie brome (*Bromus kalmii*), prairie dropseed (*Sporobolus heterolepis*), and bent grass (*Agrostis alba palustris*), all C=10, occur in this unit. Several small wetland areas occur within this unit and are dominated by sedges (*Carex spp.*). The floristic quality of this unit is high.

**EMU 19:** This unit consists of mesic savanna. The dominant tree species of the canopy are bur oak and white oak. Several shagbark hickory (*Carya ovata*) are also present in the canopy. The savanna community contains several species with a C=8: lady fern, narrow-leaved oval sedge, downy green sedge, and spinulose shield fern. This unit includes two basin marshes, one characterized by blue flag iris (*Iris virginica shrevei*), the other by common bur reed. These wetlands contain floating manna grass and stiff bedstraw (*Galium tinctorium*), both C=8, and false aster and grass-leaved arrowhead, both C=9. The floristic quality of this unit is moderate to high.

**EMU 20:** This unit primarily consists of unassociated woody growth, composed of woody native and non-native species. Canopy species in this unit are primarily box elder; however, a large stand of the non-native black locust also occurs in this unit. A woodland vernal pool and a basin marsh, as well as a small streamside marsh, occur in this unit. Conservative species observed in this unit include bent grass (C=10); smooth blue aster (*Aster laevis*), tall swamp marigold (*Bidens coronata*), *Boltonia latisquama recognita*, and marsh blue grass, all C=9; and lady fern,

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

swamp oval sedge (*Carex muskingumensis*), narrow-leaved oval sedge (*Lathyrus palustris*), sensitive fern, showy black-eyed susan (*Rudbeckia speciosa sullivantii*), and spinulose shield fern all, C=8. The floristic quality of this unit is moderate, trending to high.

**EMU 21:** This unit primarily consists of unassociated grasses and forbs, composed nearly entirely of non-native species. Areas of this unit were disturbed during construction of the APS and most of the unit was eliminated by the construction of the Advanced Protein Crystallization Facility. The floristic quality of this unit is low.

**EMU 22:** This unit, located within the Advanced Photon Source (APS) ring, primarily consists of unassociated grasses and forbs, with an increasing presence of non-native shrubs. This unit was graded for stormwater management during construction of the APS, directing surface flows to the south of the ring. Mesic prairie species were planted within this unit in 2004. The floristic quality of this unit is low.

**EMU 23:** This unit primarily consists of native community reconstruction and includes Wetland R and surrounding prairie. The wetland was constructed in 1991 as mitigation under a U.S. Army Corps of Engineers permit, using topsoil salvaged from a wetland destroyed during APS construction. Reconstructed plant communities present in this unit include permanent pond, basin marsh, wet prairie, wet-mesic prairie, and mesic prairie. The unit contains floating manna grass, white water crowfoot (*Ranunculus longirostris*), wild quinine, dodder (*Cuscuta polygonorum*), and side-oats grama (*Bouteloua curtipendula*), all C=8; grass-leaved arrowhead (*Sagittaria graminea*), rattlesnake master, smooth blue aster (*Aster laevis*), and false aster (*Boltonia latisquama recognita*), all C=9; and prairie dropseed, C=10. The eastern section of this unit includes a drainage swale characterized by common reed and narrow-leaved cattail. The floristic quality of this unit is high.

**EMU 24:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy is white oak. Sensitive fern (*Onoclea sensibilis*), purple milkweed (*Asclepias purpurascens*), narrow-leaved oval sedge, marsh St. John's wort (*Hypericum virginicum fraseri*), and wild quinine, all C=8; and beaked agrimony (*Agrimonia rostellata*) and low bindweed (*Convolvulus spithamaeus*), both C=10, occur in the savanna. A woodland vernal pool is located in this unit and has a canopy composed mostly of eastern cottonwood, with silver maple (*Acer saccharinum*) and the non-native catalpa (*Catalpa speciosa*) becoming dominant in the sub-canopy. The floristic quality of this unit is moderate to high.

**EMU 25:** This unit is primarily composed of plantations of white pine and jack pine. Areas of unassociated woody growth and unassociated grasses and forbs also cover large areas of this unit. The floristic quality of this unit is low to moderate.

**EMU 26:** This unit primarily consists of mesic and dry-mesic savanna. The dominant tree species of the canopy are white oak and bur oak, with several large red oak and black oak present. A small area of jack pine is located in the western part of this unit. Several small wetlands supporting wet prairie or woodland vernal pool communities occur in the savanna. A

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

streamside marsh is located in this unit, which is characterized by narrow-leaved cattail. Larvae of the Hine's Emerald Dragonfly, a federally and state-listed endangered species, were discovered in this wetland. Sensitive fern (*Onoclea sensibilis*), purple milkweed, Short's aster (*Aster shortii*), and lady fern, all C=8; poke milkweed (*Asclepias exaltata*) and few-fruited gray sedge (*Carex oligocarpa*) both C=9; and low bindweed, beaked agrimony, and bent grass, all C=10, occur in the savanna. The floristic quality of this unit is high.

**EMU 27:** This unit primarily consists of mesic and dry-mesic savanna. The dominant tree species of the canopy are white oak, red oak, and black oak. The westernmost part of this unit shows evidence of disturbance and includes areas of unassociated woody growth. A small woodland vernal pool is located in the northeastern corner of this unit. The floristic quality of this unit is low to moderate.

**EMU 28:** This unit is primarily composed of jack pine plantations. Areas of unassociated woody growth composed nearly entirely of non-native species (characterized by box elder, and unassociated grasses and forbs) also cover large areas of this unit. A basin marsh, which receives drainage from the 300 Area, is located in this unit and is characterized by narrow-leaved cattail. Spinulose shield fern, C=8; rough clustered sedge (*Carex cephaloidea*), C=9; and beaked agrimony, C=10, occur in this unit. The floristic quality of this unit is low.

**EMU 29:** This unit primarily consists of mesic and dry-mesic savanna. The dominant tree species of the canopy are white oak, black oak, and bur oak. A large stand of the non-native black locust occurs in the southern section of this unit. Areas of unassociated grasses and forbs, composed primarily of non-native species, occur within the northern section of this unit. Narrow-leaved oval sedge, false pennyroyal, and showy black-eyed susan (*Rudbeckia speciosa sullivantii*), all C=8; and prairie dropseed and beaked agrimony, both C=10, occur in this unit. The floristic quality of this unit is low to moderate.

**EMU 30:** This unit primarily consists of unassociated grasses and forbs, nearly entirely non-native species. Portions of this unit had been planted with jack pine, however, few individuals remain. Some areas in the southeast part of this unit were disturbed when ravines were filled in during construction of the 300 Area. False pennyroyal, prairie sunflower (*Helianthus rigidus*), and prairie blazing star, all C=8; false aster, C=9; and prairie dropseed, C=10, occur in this unit. The floristic quality of this unit is low.

**EMU 31:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy are white oak and bur oak, with several large red oak present. A woodland vernal pool is located in this unit and has a canopy composed mostly of eastern cottonwood. The South Branch of Freund Brook forms the north boundary of this unit. Sycamore, C=9, and beaked agrimony, C=10, occur in this unit. The floristic quality of this unit is moderate to high.

**EMU 32:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy are white oak and bur oak. This unit was mowed regularly until 2005 and very few native species remain in the understory. Areas of unassociated grasses and forbs are located in the eastern part

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

of this unit. A streamside marsh, characterized by narrow-leaved cattail, conveys surface water from the 200 Area to the North Branch of Freund Brook. Several acres in the eastern part of this unit were cleared and graded for a construction project. The floristic quality of this unit is low.

**EMU 33:** This unit is composed of a mosaic of white pine, jack pine, and red pine plantations, mesic savanna, and tulip poplar planted in 1954. The dominant tree species of the savanna canopy are white oak and bur oak. Areas of unassociated grasses and forbs occur in this unit, primarily around the perimeter, as well as unassociated woody growth. A basin marsh, characterized by narrow-leaved cattail, is located in the northeast corner. The South Branch of Freund Brook flows west to east through the unit. Spinulose shield fern, C=8; sweet black-eyed susan, C=9; and beaked agrimony, C=10, occur in this unit. The floristic quality of this unit is low to moderate.

**EMU 34:** This unit consists primarily of mesic woodland and savanna. The dominant tree species of the canopy are white oak and bur oak, along with red oak in the woodland area. The western areas of this unit include black walnut planted by Argonne in 1954. This unit contains several species with a C=8: large-flowered trillium, lady fern, sensitive fern, narrow-leaved oval sedge, and wood sandwort (*Arenaria lateriflora*); as well as beaked agrimony and red mulberry (*Morus rubra*), both C=10. Several small wetlands supporting wet prairie communities are located within the savanna. Three wetlands formed by stone dams constructed on Freund Brook are located in this unit. The dam failed at the middle wetland in 1996, reducing this wetland to the stream channel. The other two wetlands include streamside marshes. The lower wetland also includes a naturalized pond. These wetlands are characterized primarily by reed canary grass and common reed. The floristic quality of this unit is high, and this unit is the highest in quality.

**EMU 35:** This unit primarily consists of mesic woodland and savanna. The dominant tree species of the canopy are white oak and bur oak. This unit contains two species with a C=8: large-flowered trillium and false mermaid (*Floerkea proserpinaoides*); and beaked agrimony, C=10. The floristic quality of this unit is moderate to high.

**EMU 36:** This unit primarily consists of unassociated grasses and forbs, composed mostly of non-native species. Portions of this unit had been planted with jack pine, however, few individuals remain. The floristic quality of this unit is low.

**EMU 37:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy are white oak and bur oak. This unit contains large-flowered trillium and narrow-leaved oval sedge, both C=8, and stout blue-eyed grass (*Sisyrinchium angustifolium*), C=10. Sawmill Creek, a perennial stream, flows through this unit, with streamside marsh communities occurring intermittently along its banks. Small isolated marshes occur within the floodplain. The floristic quality of this unit is high.

**EMU 38:** This unit contains areas of unassociated grasses and forbs as well as areas of native community reconstruction. This area had been significantly disturbed during the early development of the Argonne site. Most of this unit has been planted with prairie species and

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

much of the area contains a combination of native and non-native species. The oldest plantings, in the southeast portion of the unit, support a mesic prairie community dominated by big bluestem and Indian grass. Prairie milkweed (*Asclepias sullivantii*), white wild indigo (*Baptisia leucantha*), side oats grama, pale purple coneflower, and wild quinine, all C=8; Rattlesnake master and sweet black-eyed susan, both C=9; and prairie dropseed, C=10, occur in the prairie. The floristic quality of this unit is low to moderate.

**EMU 39:** This unit consists of areas of unassociated grasses and forbs, and areas of unassociated woody growth, both composed mostly of non-native species. Non-native shrubs are increasing throughout the unit and many young black oak have become established. A small stream and associated floodplain run through this unit. The floristic quality of this unit is low.

**EMU 40:** This unit primarily consists of unassociated woody growth. The dominant species along a small intermittent stream are sandbar willow (*Salix interior*) and eastern cottonwood. Also present are remnants of jack pine plantations which include a large component of non-native shrubs. The floristic quality of this unit is low.

**EMU 41:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy are white oak and bur oak. The savanna extends into Waterfall Glen Forest Preserve. The floristic quality of this unit is low to moderate.

**EMU 42:** This unit is composed of a mosaic of mesic savanna, unassociated grasses and forbs, unassociated woody growth, and streamside marsh, as well as areas of native community reconstruction. The dominant species of the savanna canopy are white oak and bur oak; the dominant marsh species is reed canary grass. False pennyroyal and side oats grama, both C=8, and swamp rose mallow (*Hibiscus palustris*), C=9, occur in this unit. The floodplain of Sawmill Creek, a perennial stream, comprises much of this unit and includes two wetlands, both streamside marshes. The floristic quality of this unit is moderate.

**EMU 43:** This unit was planted with jack pine in 1955, however, most of the area is now considered unassociated woody growth, with black cherry and box elder composing most of the tree canopy. A basin marsh is located in this unit. Reed canary grass is the dominant species. The floristic quality of this unit is low to moderate.

**EMU 44:** This unit includes mesic savanna, unassociated woody growth, and unassociated grasses and forbs. The dominant canopy species of the savanna are bur oak and white oak. A few individuals of jack pine, black walnut, and green ash planted in 1954 remain in this unit. The North Branch of Freund Brook flows through the savanna. The narrow floodplain supports a community of willows (*Salix spp.*) and eastern cottonwood. Beaked agrimony, C=10, occurs in this unit. The floristic quality of this unit is low to moderate.

**EMU 45:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy are white oak and bur oak. A streamside marsh dominated by narrow-leaved cattail, is located in the northwest corner of this unit; A woodland vernal pool, is located in the eastern section.

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Sensitive fern, bristly cattail sedge (*Carex frankii*), and narrow-leaved oval sedge, all C=8; marsh blue grass (*Poa palustris*), C=9; and beaked agrimony, C=10, occur in this unit. The floristic quality of this unit is moderate to high.

**EMU 46:** This unit primarily consists of mesic savanna. The dominant tree species of the canopy are white oak and bur oak. The western section includes an area of unassociated woody growth. Sweetgum, planted by Argonne in 1954, occur in the eastern section of this unit. A zone of unassociated grasses and forbs is located north of Outer Circle Road. A wetland, located in a drainage ditch along Outer Circle Road, continues north through the savanna and conveys surface water from the 200 Area to an unnamed tributary of Sawmill Creek. Lady fern, narrow-leaved oval sedge, spinulose shield fern, and sensitive fern, all C=8; poke milkweed and marsh blue grass, both C=9; and prairie sundrops (*Oenothera pilosella*) and beaked agrimony, both C=10, occur in this unit. The floristic quality of this unit is moderate to high.

**EMU 47:** This unit primarily consists of areas of unassociated woody growth, basin marsh, and native community reconstruction. The former Lime Sludge Pond, this unit is a remnant of the Sawmill Creek floodplain that had been diked off and used for the storage of lime sludge, a byproduct of Argonne's steam generation process. Following removal of the lime sludge in 2000, the area was planted with native species to create mesic, wet-mesic, and wet prairie communities. The central area of this unit is used for the disposal of soils excavated from construction projects around the site. Basin marsh and a naturalized pond occur in the southern part of this unit. A narrow band of mesic savanna occurs along what had been the former bank of Sawmill Creek. The channelized creek forms the eastern boundary of this unit. Water star grass (*Heteranthera dubia*) and false pennyroyal, both C=8; and false aster and Pursh's tufted bulrush (*Schoenoplectus [=Scirpus] purshianus*), both C=9, have been observed in this unit. The floristic quality of this unit is low to moderate.

**EMU 48:** This unit primarily consists of a red pine plantation. Areas of unassociated grasses and forbs, composed mostly of non-native species, also cover portions of this unit. The channelized segment of Sawmill Creek forms the western boundary of this unit. The floristic quality of this unit is low.

**EMU 49:** This unit primarily consists of mesic savanna. The dominant species of the canopy are white oak and bur oak. Areas of unassociated woody growth, and unassociated grasses and forbs also occur in this unit. Sawmill Creek forms the western boundary of this unit. The floristic quality of this unit is low.

## Appendix C: Legislative and Regulatory Requirements for Natural Resource Management on Federal Lands

**Note:** This section has been copied from the *Oak Ridge National Laboratory Wildlife Management Plan* and adjusted to make it relevant to Argonne. The Department of Energy (DOE) is committed to land management and conservation and works to be a good steward of its land and the natural resources on it. A number of regulatory requirements direct DOE's Land Use and Natural Resource management including:

- Federal laws, executive orders, and presidential memoranda;
- DOE directives (e.g., orders, guidance);
- Illinois state laws and regulations

### Federal Laws

A number of federal laws require or encourage federal agencies to actively manage natural resources, including wildlife, on their lands. Regulations that have the force of law implement many of these federal laws, and DOE must also comply with them. (Summaries of some of these laws and their implementing regulations are available on the DOE website at <https://www.energy.gov/em/long-term-stewardship-related-information>.) The following laws are listed in chronological order of their initial passage by Congress. Each law has been amended at least once; the discussions below reflect the most recent versions of each law, including all amendments.

#### Migratory Bird Treaty Act (1918)

The Migratory Bird Treaty Act (MBTA) (Title 16, United States Code [USC], Sects. 703–712) of 1918 implements treaties—signed by the United States and Canada, Japan, Mexico, and the former Soviet Union—for the protection of shared migratory bird resources. The act protects migratory birds by governing the taking, killing, possession, transportation, and importation of such birds; their eggs, parts, and nests; and any product, manufactured or not, from such items. The USFWS has developed a list of migratory birds that are protected under the act. The list can be found in Title 50, Code of Federal Regulations (CFR), Part 10.13, or at the website, [www.gpo.gov/fdsys/pkg/FR-2010-03-01/pdf/2010-3294.pdf](http://www.gpo.gov/fdsys/pkg/FR-2010-03-01/pdf/2010-3294.pdf). (The latter list provides updated scientific and common names that conform to the most recent taxonomy, with cross references to the names in the CFR list.) The USFWS has also published a list of 125 bird species (Title 70, Federal Register [FR], Part 12710, March 15, 2005, available at <http://migratorybirds.usfws.gov>) that are not native to the United States and, therefore, are not protected under the MBTA.

## **Fish and Wildlife Coordination Act (1934)**

The Fish and Wildlife Coordination Act (FWCA) (16 USC 661–667e) of 1934 recognizes the vital contribution of wildlife resources, both animals and plants, to the nation. The act requires federal agencies to consult with the USFWS and appropriate state wildlife agencies when they plan to conduct any activity involving the impoundment, diversion, deepening, control, or modification of a body of water. It requires that equal consideration and coordination be given to conservation of fish and wildlife as to other water resource values during project planning involving water bodies larger than 10 acres (4 ha) in size. Federal agencies must assess the impacts of their planned activities on wildlife resources and modify project plans by justifiable means and measures to prevent loss or damage to those resources. Reports and recommendations prepared by these agencies are to document project effects on wildlife and identify measures that can be adopted to prevent loss or damage to wildlife resources.

## **Bald Eagle Protection Act (1940)**

The Bald Eagle Protection Act (16 USC 668–668d) of 1940 protects bald and golden eagles by prohibiting, except under certain specified conditions, the taking or possession of and commerce in such birds. (Although the short title of the act mentions only bald eagles, its provisions also apply to golden eagles.) The act imposes criminal and civil penalties on anyone who, unless exempted, takes; possesses; sells; purchases; barter; offers to sell, purchase, or barter; transports; exports; or imports at any time or in any manner a bald or golden eagle, alive or dead, or any part, nest, or egg of those eagles. “Take” means to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. “Transport” means to convey or carry by any means or to deliver or receive for conveyance.

## **Sikes Act (1960)**

The Sikes Act (16 USC 670a–670o) of 1960 calls for cooperation with state fish and game agencies in planning and managing wildlife habitat on federal lands. This act specifically mentions lands controlled by DOE. It states that the “Secretary of the Interior shall develop, with the prior written approval of the Atomic Energy Commission (AEC) [now the Department of Energy], a comprehensive plan for conservation and rehabilitation programs to be implemented on public land under the jurisdiction of the Chairman” of the AEC (now the Secretary of DOE). “Each such plan shall be developed after the Secretary of the Interior makes, with the prior written approval of the Chairman ... and in consultation with the state agencies, necessary studies and surveys of the land concerned to determine where conservation and rehabilitation programs are most needed.” The act further states that “each comprehensive plan developed ... shall be consistent with any overall land-use and management plans for the lands involved.” Programs shall include, but not be limited to, specific habitat-improvement projects and related activities that provide adequate protection for species of fish, wildlife, and plants considered threatened or endangered.

## **National Environmental Policy Act (1969)**

The National Environmental Policy Act (NEPA) (42 USC 4321–4347) of 1969 declares that it is a national policy to encourage productive and enjoyable harmony between people and the environment, and to promote efforts to better understand and prevent damage to ecological systems and natural resources that are important to the nation. In the act, Congress stated that it is the continuing responsibility of the federal government to use all practicable means to create and maintain conditions under which people and nature can exist in productive harmony and to fulfill the social, economic, and other requirements of present and future generations. NEPA requires all federal agencies to consider the effects of their actions on the environment; employ an interdisciplinary process in decision making; and develop the means to ensure that unquantified environmental values are given appropriate consideration, along with the economic and technical aspects of the actions. Thus, when DOE proposes an action, it must develop a NEPA document (e.g., categorical exclusion, environmental assessment, environmental impact statement) to consider the potential impacts. Hence, the activity conducted under this plan has site oriented categorical exclusions — ASO-CX-344 Habitat Maintenance Activities. Compliance with several other wildlife and conservation acts (e.g., Endangered Species Act [ESA], FWCA) is integrated within Argonne’s NEPA process.

## **Endangered Species Act (1973)**

The purpose of the ESA (16 USC 1531–1544) of 1973 is to preserve plants and animals facing extinction. It mandates the conservation of proposed and listed Threatened and Endangered (T&E) species and the designated critical habitats supporting them. The act prohibits the harm, harassment, trade, or capture of endangered species and provides for the protection of threatened species, those species that may become endangered. The USFWS maintains lists of designated T&E species in 50 CFR 17 and updates them as needed.

Section 7 requires all federal agencies to ensure that any action they authorize, fund, or carry out does not jeopardize the continued existence of a T&E species or result in the destruction or adverse modification of designated critical habitats that are important in conserving those species. The USFWS and National Marine Fisheries Service (NMFS) have established informal and formal consultation procedures in 50 CFR 402, “Consultation by Federal Agencies,” that implement this section of the act. If DOE proposes an action and if no previous NEPA documentation exists for the area involved in any alternative under consideration, a biological survey and evaluation might be required to determine if any T&E species are or could be present. Initial consultation with the USFWS can take from 30 to 45 days. However, field surveys, if required, could extend in excess of one year to identify seasonal issues. If a listed T&E species might be affected by the action, a detailed biological assessment of potential impacts can be prepared independently or concurrently with the NEPA document and included as an appendix to that document.

A biological opinion issued by USFWS at the conclusion of consultation can include a statement authorizing taking of a T&E species that might occur incidental to an otherwise legal activity.

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Section 7(a) of the act requires federal agencies to use their authorities to further the purposes of the act by carrying out programs to conserve listed T&E species. Section 9 lists actions that are prohibited under the act, including damaging or destroying endangered plants on federal lands or taking a listed species unless such taking is incidental to an otherwise legal activity and has been specifically allowed.

## **Clean Water Act (1977)**

The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under the CWA, EPA has implemented pollution control programs such as setting wastewater standards for industry. It has also set water quality standards for all contaminants in surface waters. Also, it ensures drinking water is safe, and restores and maintains oceans, watersheds, and their aquatic ecosystems to protect human health, support economic and recreational activities, and provide healthy habitat for fish, plants, and wildlife.

The CWA made it unlawful to discharge any pollutant from a point source into navigable waters without a permit. EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls discharges. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

## **Fish and Wildlife Conservation Act**

The FWCA (16 USC 2901–2912) of 1980 is commonly known as the “Nongame Act.” The purpose of the act is to provide financial and technical assistance to states for the development, revision, and implementation of conservation plans and programs for nongame fish and wildlife. It encourages federal agencies, such as DOE, to use their statutory and administrative authority to protect and promote the conservation of nongame fish and wildlife and their habitats. The USFWS shares responsibility for administering the ESA with the NMFS in the Department of Commerce. NMFS is only responsible for marine species. Public Law 106-224 repealed Sections 2801-2813 on June 20, 2000.

## **Comprehensive Environmental Response, Compensation, and Liability Act**

The purpose of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (also referred to as “Superfund”) (42 USC 9601 et seq.) is to clean up sites contaminated by hazardous-substance releases and ensure that the public is compensated for natural-resource injuries caused by such releases. The act designates the President of the United States as the trustee on behalf of the public for federally protected or managed natural resources. This responsibility has been delegated to federal agencies, including DOE. (See discussion of Executive Order 12580, below.) The act defines natural resources as “land, fish, wildlife, biota, air, water, groundwater, drinking supplies, and other such resources.”

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

As a natural-resource trustee for land it manages, DOE has a broad responsibility for such natural resources under its jurisdiction. After notification or discovery of a natural-resource injury, loss, or threat, DOE will take appropriate actions. These actions can include conducting a preliminary survey of areas affected by a discharge or release to determine if natural resources are or might be impacted; cooperating with the on-scene coordinator/regional project manager in coordinating assessments, investigations, and planning; and carrying out a plan for restoration, rehabilitation, replacement, or acquisition of equivalent natural resources. DOE, as a natural-resource trustee, can assess damages "... for injury to, destruction of, or loss of natural resources ..." following a release of hazardous substances. Assessments are made on the basis of "residual" injury that was not or could not be addressed by the selected remedy.

## **Plant Protection Act (2000)**

The Plant Protection Act regulates the control of plant pathogens and noxious weed introductions and populations. The Act is administered by the US Department of Agriculture and enforced by the USDA's Animal and Plant Health Inspection Service. This broad legislation addresses the destructive impact that a wide array of organisms can have when introduced into the nation. Further executive guidance for this Act is found in Executive Order 13751, "Safeguarding the Nation from the Impact of Invasive Species."

## **Energy Independence and Security Act (2007)**

The objective of the Energy Independence and Security Act (EISA) is to move the United States toward greater energy independence and security, increase the production of clean renewable fuels and the efficiency of products, buildings, and vehicles, promote research on and deploy greenhouse gas capture and storage options, improve the energy performance of the Federal Government, and increase U.S. energy security, develop renewable fuel production, and improve vehicle fuel economy. EISA reinforces the energy reduction goals for federal agencies put forth in Executive Order 13423, as well as introduces more aggressive requirements. The three key provisions enacted are the Corporate Average Fuel Economy Standards, the Renewable Fuel Standard, and the appliance/lighting efficiency standards. EPA is committed to developing, implementing, and revising both regulations and voluntary programs under the following subtitles in EISA, among others increased Corporate Average Fuel Economy Standards, Federal Vehicle Fleets, Renewable Fuel Standard, Biofuels Infrastructure, Carbon Capture and Sequestration, and storm water management.

## **Other Laws**

DOE and its operating contractors are also subject to laws and regulations pertaining to radiation (e.g., Atomic Energy Act) and contaminants regulated under other laws (e.g., Resource Conservation and Recovery Act, Contaminated Substances Control Act) that are present on its lands as a result of past and continuing activities. Although this plan is not intended to deal with such issues, where relevant, reference will be made to such instances relating to natural resources.

## Executive Orders and Presidential Memoranda

Executive orders and presidential memoranda also provide direction to DOE in managing its lands. The following summaries cover those that pertain, directly or indirectly, to wildlife management. A guidance document has been prepared to assist DOE Program and Field Organizations in understanding and meeting their natural-resource-trustee responsibilities, “Integrating Natural Resource Damage Assessment and Environmental Restoration Activities at DOE Facilities.”

### Executive Order 11990: Protection of Wetlands

Executive Order 11990, signed May 24, 1977, (published May 25, 1977, at 42 FR 269614) establishes wetland protection as the official policy of all federal agencies. The order directs each agency to provide leadership, “to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.” The executive order applies to federally undertaken, financed, or assisted construction and improvements in or with significant impacts on wetlands. Agencies are to avoid adverse impacts on wetlands wherever there is a practicable alternative. Work conducted or funded by a federal agency should not call for new construction in wetlands unless the head of the agency finds that there is no practicable alternative to such construction and the proposed action includes all practicable measures to minimize damage to wetlands. In making this finding, the head of the agency can take into account economic, environmental, and other pertinent factors. Agencies are also required to provide for early public review of any plans or proposals for new construction in wetlands.

Under this executive order, DOE must preserve and enhance the natural and beneficial values of wetlands when (1) acquiring, managing, and disposing of its lands and facilities; (2) undertaking, financing, or assisting construction and improvements; and (3) conducting any activities and programs affecting land use, including, but not limited to, water and related land-resources planning, regulating, and licensing activities.

In carrying out the activities described above, DOE must consider a proposal’s effect on the survival and quality of the wetlands. Among the values of wetlands to be considered are maintenance of natural systems, including conservation and long-term productivity of existing flora and fauna; species and habitat diversity and stability; hydrologic utility; fish, wildlife, timber, food, and fiber resources; and scientific uses. DOE’s regulations implementing this executive order are found in 10 CFR 1022, “Compliance with Floodplain and Wetland Environmental Review Requirements.” They can be accessed at <http://cfr.regstoday.com/10cfr1022.aspx>.

### Executive Order 13112: Invasive Species

This executive order, signed February 3, 1999, (published February 8, 1999, at 64 FR 6183) directs all federal agencies to address invasive species concerns and refrain from actions likely to increase invasive species problems. The purpose of this executive order is to prevent the introduction of invasive species; to provide for their control; and to minimize the economic, ecological, and human health impacts such species cause. The Invasive Species Management

## NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Plan (Appendix E) implements this executive order and interacts with this wildlife management plan to protect ORR wildlife from the impacts of invasive species. This Order was updated on December 5, 2016 as Executive Order O 13751, “Safeguarding the Nation from the Impacts of Invasive Species.”

### **Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds**

This executive order, signed January 10, 2001, (published January 17, 2001, at 66 FR 3853) requires federal agencies—within existing budgets, missions, and responsibilities—to avoid or minimize the negative impact of their actions on migratory birds (see Migratory Bird Treaty Act summary earlier in this Appendix). Agencies must actively protect birds and their surroundings by, for example, restoring and enhancing habitat, preventing or abating pollution affecting birds, and incorporating migratory-bird conservation into agency planning processes. The Memorandum of Understanding (MOU) commits DOE to cooperate with the USFWS to “substantially contribute to the conservation and management of migratory birds and their habitats.” It affirms DOE’s commitment to “[take] its environmental stewardship role seriously and [advocate] a proactive management stance toward the natural environment.”

The MOU details the individual and collective obligations of DOE and the USFWS, as follows. Both DOE and the USFWS shall:

- protect, restore, enhance, and manage habitats of migratory birds;
- promote collaborative inventorying, monitoring, management studies, research, and information exchange related to the conservation of migratory birds and management of their habitats;
- integrate migratory-bird-conservation principles, measures, and practices into agency activities;
- protect, restore, enhance, and manage habitats of migratory birds;
- incorporate migratory-bird-habitat and population-management objectives and recommendations into planning processes, including DOE site planning documents; and
- recognize and promote the ecological, economic, and recreational values of migratory birds into outreach and educational materials and activities.

## **U.S. Department of Energy Orders**

### **Order 430.1C Real Property**

Department of Energy Order 430.1C is intended to establish a data-driven, risk-informed, performance-based approach to the life-cycle management of real property assets that aligns the real property portfolio with DOE-mission needs; acquire, manage, positively account for, and dispose of real property assets in a safe, secure, cost-effective, and sustainable manner; and ensure the real property portfolio is appropriately sized, aligned, and in the proper condition to support efficient mission execution.

This broad statement is the introductory paragraph of the Order. A thorough reading of the Order, its history and predecessors, and its connection to all other related Federal statutes and mandates reveals the Department's commitment to effective management of the nation's resources.

## Appendix D: Site Landscape Plant List

The Site Landscape Plant List incorporates plant species native to DuPage County, Illinois, and also found at Waterfall Glen Forest Preserve and the Argonne site. These species are appropriate for capital improvement projects, decorative landscapes, and landscape screening and are available from commercial nurseries. This selection is intended to identify native plant species that have been able to provide horticulture value, meet sustainable landscape specifications, and fulfill the intention of blending designs into the greater landscape. Landscape designs for projects may include non-native species not listed here, given that the non-native selection does not have invasive qualities or potential to corrupt the integrity of native genotypes through cross-pollination. Final review and approval of a project planting design and species list shall be granted by the Argonne Natural Resources Manager for all projects.

### Grasses

*Andropogon gerardii*/big bluestem\*\*  
*Andropogon scoparius*/little bluestem\*\*  
*Bouteloua curtipendula*/side oats grama\*  
*Cinna arundinacea*/common wood reed\*\*  
*Elymus canadensis*/Canada wild rye\*\*  
*Elymus virginicus*/Virginia wild rye\*\*  
*Eragrostis spectabilis*/purple lovegrass\*

*Glyceria striata*/fowl manna grass\*\*w  
*Hystrix patula*/bottlebrush grass\*\*  
*Juncus tenuis*/path rush\*  
*Panicum virgatum*/switch grass\*  
*Sorghastrum nutans*/indian grass\*  
*Spartina pectinata*/prairie cord grass\*w  
*Sporobolus heterolepis*/prairie dropseed

### Forbs

*Allium cernuum*/nodding wild onion\*\*  
*Anemone cylindrica*/thimbleweed\*\*  
*Aquilegia canadensis*/wild columbine\*\*\*  
*Arisaema triphyllum*/jack-in-the-pulpit\*\*\*  
*Asarum canadense*/wild ginger\*\*\*  
*Asclepias incarnata*/swamp milkweed\*w  
*Asclepias tuberosa*/butterfly weed\*\*  
*Aster azureus*/sky blue aster\*\*  
*Aster ericoides*/heath aster\*  
*Aster laevis*/smooth blue aster\*\*  
*Aster lateriflorus*/side-flowering aster\*\*\*  
*Aster novae-angliae*/New England aster\*\*w  
*Aster shortii*/Short's aster\*\*  
*Athyrium filix-femina var. michauxii*/lady fern\*\*\*  
*Campanula americana*/tall bellflower\*\*  
*Clematis virginiana*/Virgin's bower\*\*\*  
*Coreopsis lanceolata*/sand coreopsis\*  
*Desmodium canadense*/showy tick trefoil\*\*  
*Dicentra cucullaria*/dutchman's breeches\*\*\*  
*Dodecatheon meadia*/shooting star\*\*

*Echinacea pallida*/pale purple coneflower\*  
*Echinacea purpurea*/purple coneflower\*\*  
*Eryngium yuccifolium*/rattlesnake master\*  
*Eupatorium maculatum*/spotted joe pye weed\*w  
*Eupatorium purpureum*/purple joe pye weed\*\*  
*Geranium maculatum*/wild geranium\*\*\*  
*Geum triflorum*/prairie smoke\*  
*Heliopsis helianthoides*/false sunflower\*\*  
*Heuchera richardsonii*/alumroot\*\*  
*Hierochloa odorata*/sweet grass\*\*w  
*Hydrophyllum virginica*/Virginia waterleaf\*\*\*  
*Iris virginica var. shrevei*/blue flag iris\*\*w  
*Lespedeza capitata*/round-head bush clover\*  
*Liatris aspera*/rough blazing star\*  
*Liatris pycnostachya*/prairie blazing star\*  
*Lilium michiganense*/Michigan lily\*  
*Lobelia cardinalis*/cardinal flower\*\*w  
*Lobelia siphilitica*/great blue lobelia\*\*w  
*Lobelia spicata*/pale spiked lobelia\*  
*Monarda fistulosa*/wild bergamot\*\*

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

*Parthenium integrifolium*/wild quinine\*  
*Penstemon digitalis*/foxglove beard tongue\*\*  
*Petalostemum candidum*/white prairie clover  
*Petalostemum purpureum*/purple prairie clover\*  
*Phlox divaricata*/blue phlox\*\*\*  
*Phlox pilosa* var. *fulgida*/prairie phlox\*  
*Physostegia virginiana* var. *arenaria*/prairie obedient plant\*  
*Physostegia virginiana* var. *speciosa*/showy obedient plant\*\*w  
*Podophyllum peltatum*/May apple\*\*\*  
*Polemonium reptans*/Jacob's ladder\*\*  
*Polygonatum canaliculatum*/Solomon's seal\*\*\*  
*Potentilla arguta*/prairie cinquefoil\*  
*Ratibida pinnata*/yellow coneflower\*  
*Rudbeckia hirta*/black-eyed susan\*\*

## Shrubs:

*Amorpha canescens*/leadplant\*  
*Baptisia leucantha*/white wild indigo\*\*  
*Ceanothus americanus*/New Jersey tea\*\*  
*Cornus obliqua*/blue-fruited dogwood\*\*w  
*Cornus sericea*/stolonifera/red-osier dogwood\*\*w  
*Corylus americana*/American hazelnut\*  
*Euonymus atropurpureus*/wahoo\*\*\*  
*Hamamelis virginiana*/witch hazel\*\*\*  
*Lindera benzoin*/spicebush\*\*\*w

## Trees:

*Carya cordiformis*/bitternut hickory\*\*  
*Carya ovata*/shagbark hickory\*  
*Cercis canadensis*/redbud\*\*  
*Crataegus coccinea*/scarlet hawthorn\*\*  
*Crataegus crus-galli*/cockspur hawthorn\*\*  
*Crataegus mollis*/downy hawthorn\*\*  
*Gymnocladus dioica*/Kentucky coffee tree\*\*  
*Malus ioensis*/Iowa crab\*\*

*Sanguinaria canadensis*/blood root\*\*\*  
*Silphium integrifolium* *deamii*/rosinweed\*  
*Silphium laciniatum*/compass plant\*  
*Smilacina racemosa*/false Solomon's seal\*\*\*  
*Solidago juncea*/early goldenrod\*  
*Solidago nemoralis*/grey goldenrod\*  
*Solidago riddellii*/Riddell's goldenrod\*w  
*Solidago rigida*/stiff goldenrod\*  
*Solidago ulmifolia*/elm-leaved goldenrod\*\*\*  
*Tradescantia ohiensis*/spiderwort\*\*  
*Trillium grandiflorum*/great white trillium\*\*\*  
*Trillium recurvatum*/red trillium\*\*\*  
*Vernonia fasciculata*/ironweed\*w  
*Veronicastrum virginicum*/culver's root\*\*  
*Zizia aurea*/golden alexanders\*\*

*Physocarpus opulifolius*/ninebark\*\*w  
*Rosa blanda*/early wild rose\*  
*Rosa carolina*/pasture rose\*  
*Rosa setigera*/Illinois rose\*\*  
*Sambucus canadensis*/elderberry\*\*w  
*Viburnum acerifolium*/maple-leaved arrow-wood\*\*  
*Viburnum lentago*/nannyberry\*  
*Viburnum prunifolium*/black haw\*\*  
*Viburnum rafinesquianum*/downy arrow-wood\*\*

*Quercus alba*/white oak\*  
*Quercus bicolor*/swamp white oak\*\*  
*Quercus imbricaria*/shingle oak\*\*  
*Quercus macrocarpa*/bur oak\*  
*Quercus muhlenbergii*/chinquapin oak  
*Quercus rubra*/red oak\*\*  
*Quercus velutina*/black oak\*\*

\* needs full sun

\*\* tolerates partial shade/full sun

\*\*\* tolerates full shade

w tolerates wet soil

## Appendix E: Invasive Species Management

### Argonne National Laboratory Invasive Species Management

This document complements Argonne National Laboratory’s Natural Resource Management Plan (NRMP). It is intended here to discuss approaches to invasive species control measures more in depth than the NRMP as intended in Executive Order 13715. In 2008 the National Invasive Species Council (NISP) prepared the National Invasive Species Management Plan 2008–2012 for federal facilities. This comprehensive work has been adapted to the Argonne site with consideration to other prevailing orders and directives as of 2014. Reference that document and additional works from the NISP for greater detail on these recommendations.

Argonne’s habitat management and invasive species control efforts have been evaluated under the National Environment and Policy Act. Categorical exclusions (CXs) have been created for the activity allowing for the work with limitations, primarily ASO-CX-344 Habitat Maintenance Activities but also ASO-CX-345 Routine Grounds and Maintenance Activity. Invasive species management must rely on local knowledge of the site and regions. The State of Illinois has developed management strategies through the Illinois Nature Preserves Commission (INPC). INPC’s Vegetation Management Manual has been integrated into Argonne’s invasive species management plan.

### Argonne and the National Invasive Species Plan

The National Invasive Species Management Plan prepared a strategic framework for federal agencies to follow in order to address the national problem of invasive species impacts to natural and human systems as directed by Executive Order 13715. The framework is adaptable to the local level for federal facilities, and the following text is a series of excerpts and adapted language of that document, others previously mentioned, and relevant language for more recent Executive Orders on climate change and facility management.

Long-range strategic planning is necessary to address complex invasive species issues. This Plan establishes five long-term and continuous “Strategic Goals” that can be utilized to focus Argonne National Laboratory’s efforts for invasive species control:

1. Prevention (P),
2. Early Detection and Rapid Response (EDRR),
3. Control and Management (CM),
4. Restoration (R), and
5. Organizational Collaboration (OC).

The strategic goals are ongoing and serve as guideposts for managing invasive species.

## Prevention

Prevention is the first line of defense. It can be the most cost-effective approach because once a species becomes widespread, controlling it may require significant and sustained expenditures. Therefore, public investment in prevention tools, resources, and infrastructure is indispensable in protecting human health, agriculture, and natural resources. Long-term success in prevention will reduce the rate of introduction, the rate of establishment and the damage from additional invasive species. Measuring success requires accurate baseline data and monitoring systems to measure long-term trends. This will substantially contribute toward the accomplishment of the Strategic Goals and Objectives.

*This is Goal 4 of the Natural Resources Management Plan — Prevent introduction and establishment of invasive species to reduce their impact on the environment, economy and health.*

## Early Detection and Rapid Response

There are three components of EDRR—Early Detection (ED), Rapid Assessment (RA), and Rapid Response (RR). In order to conduct EDRR, invasive species populations must first be found. Specimens have to be authoritatively identified and the boundaries of the infestations determined. These essential Early Detection (ED) efforts require resources, planning, and coordination.

**Rapid Assessment (RA)** encompasses actions necessary to determine the appropriate response, including the current and potential range of the invasive species' infestation(s). The RA process identifies the invasive species interdiction options, timing, and overall strategy for actions and provides reliable information to the public. Advanced planning that anticipates invasions and takes into account that trans-jurisdictional issues greatly expedites efforts.

**Rapid Response (RR)** is a systematic effort to eradicate or contain invasive species while infestations are still localized. RR may address totally new introductions into the site or range expanding infestations of previously established species. Timeliness is key to RR. It is critical to quickly mobilize resources to intensely control an infestation before it becomes more widely established. Invasions can rapidly overwhelm local resources. The ability to share resources across jurisdictional boundaries, form strategic partnerships, and have “ready” access to plans, funds, and technical resources are critical components of RR.

*This is Goal 2 of the Natural Resources Management Plan — Develop and enhance the capacity to identify, report and effectively respond to newly discovered/localized invasive species.*

## Control and Management

A variety of control and management tools are needed to assess, remove, and contain invasive species populations and guide management decisions. These tools are applied within coordinated and integrated invasive species management strategies that are adjusted, as needed. Lack of financial and human resources often limits the capacity to control and manage invasive species.

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

An Integrated Pest Management (IPM) approach considers the best available scientific information, updated target population monitoring information, and the effectiveness of control methods in selecting and implementing a range of complementary and environmentally sound technologies and methods to achieve desired objective(s). These methods are described in detail in the NISC Plan.

Invasive species can span geographic and jurisdictional boundaries. Their control and management requires inter-jurisdictional communication and regionally coordinated action. Information on the distribution, abundance, rates of spread, and impacts of invasive species is critical to their control. Eradication of widespread invasive species may not be feasible. Widespread invasive species are subject to control and management efforts that slow the rate of range expansion and lessen the impacts of invasive populations.

***Implement Goal 2 of the Natural Resources Management Plan — Contain and reduce the spread and populations of established invasive species to minimize their harmful impacts.***

## **Restoration**

Restoration treatments are an integral part of control and management efforts to help guard against future re-infestations and further harm. Section 2(a) (2) of Executive Order 13112 charges federal agencies to “provide for restoration of native species and habitat conditions in ecosystems that have been invaded”. Additionally, Section 4 (d) of Executive Order 13112 calls on NISC to develop guidance, in coordination with the Council on Environmental Quality (CEQ), “including the procurement, use and maintenance of native species as they affect invasive species.” New restoration guidance will be shared widely with federal, tribal, state, and private landowners and water managers.

Argonne has a Land Management and Habitat Restoration Plan (LMHRP) that recognizes the relationship between invasive species population control and habitat restoration. The control of any one or several invasive species provides a landscape for settlement of new occupant species. Ideally new species will match existing or historical native vegetation and habitat conditions. In the absence of that occupation by desirable vegetation, re-invasion by non-native invasive species is likely to occur. Habitat restoration is a dynamic endeavor with many variables required for success. It is never a one step process and will require several actions based on continuous action inputs and assessments. Such efforts are described in detail in the LMHRP.

***Implement Goals 1-3 of the Natural Resources Management Plan — Restore native species and habitat conditions and rehabilitate high-value ecosystems and key ecological processes that have been impacted by invasive species to meet desired future conditions.***

## **Organizational Collaboration**

The Chicago region is host to a number of invasive species populations and that number continues to grow. Federal facilities throughout the Chicago region host a number of invasive species populations. There is opportunity for area facility managers to collaborate with neighbors

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

and other agencies. Notwithstanding any agency's limitations, research, information sharing and data management, international cooperation, education and outreach, best practices, and inter-agency agreements are some means to collaborate and maximize existing resources for prevention, early detection and rapid response, control and management, and restoration. Where federal facilities border large areas under state, local, or non-government jurisdiction, invasive species may be impossible to manage in the absence of joint cooperation.

The Northeast Illinois Invasive Plant Partnership (NIIPP) is a cooperative weed management area (CWMA), a regional organization that brings together all interested landowners, land managers (private, city, county, state, and federal), non-profits, private entities, industry, special districts, and the public in the northeastern Illinois region for the purpose of coordinating and combining their resources, expertise, and activities for more efficient and effective management of invasive plant species across jurisdictional boundaries. The organization provides valuable information on invasive species identification, early detection map locations, and control measures, and early detection notification for new species detected and located in the Chicago region.

*Maximize organizational effectiveness and collaboration on invasive species issues among federal, state, local and tribal governments, private organizations and individuals.*

## Considerations

### Invasive species

The term invasive species is typically thought of as being applied only to plants. Many other living organisms can be regarded as invasive such as animals including insects, fungi, microorganisms, aquatic organisms, and many more. The list is extensive and they affect not only habitats, but anatomic processes, food chains, and any number of other natural system processes that have established homeostasis. At any point in time a species introduced into a system can either exploit that system or be unable to survive in that system. All of our invasive species have been able to exploit system functions. Some systems become stressed and are then defenseless to invasive species that exploit those systems as well. Habitats are functioning systems, and our most common invasive species are often plants that can exploit system resources in the absence of controls or are responding to system stresses as in the case of habitat disturbance. In all cases invasive species damage system processes and reduce system efficiency. In habitats that translates to loss of biodiversity.

### Significance

Argonne hosts both habitats and populations of invasive species all typical of the Chicago region. The Illinois Nature Preserves Commission provides a list of known invasive species in the state, which we have adapted here as many occur in the Chicago region or are already on the Argonne site. Population significance at Argonne is either not present, not significant, population stable, significant and expanding, or throughout the site. Species not present are known in the area and should be sought on site for early detection and subsequent rapid response. Species not significant may be present but have reached a limitation in population expansion or have been

controlled. Stable populations also have reached limitations, but may have a potential to expand. Only in this category is a plus (+) or minus (–) qualifier indicating a likely expansion or reduction in population. Significant and expanding populations are invasive species that have not completely invaded all possible habitats and are more or less expanding in that direction. Some species have reached the full extent of advance and are throughout the Argonne site and suitable habitats. Some populations can be stable and throughout the facility.

### **Control rank**

Most invasive species can be controlled through one or several options. There may be a most effective option that is best among a group of other variably effective options. Some options may have conditions under which they may be effective. For instance, mechanical control is variably effective on autumn olive, but the stumps must be treated with an herbicide solution that is most effective. Mechanical control may need to be integrated into a control option for autumn olive because although herbicide is most effective, herbicide application rate is diminished without mechanical effort. The six control options are ranked by three categories: most effective, conditionally effective, or non-effective.

### **Controls**

The controls for most invasive species are well-described in the literature. Chemical control is the use of a tested and approved substance for the control of a problem species. Controls are generally classified according to the group of organisms with which they control and have the suffix “icide” attached to the classification word. For instance, an herbicide is effective at controlling plants and a fungicide is effective at controlling species of fungi. Rodenticide, insecticide, and miticides are all chemical controls of a group of species. Of all the controls, chemical applications have the greatest chance of adverse impacts to the environment. Integrated Pest Management, inherent in this plan, guides practitioners to use the most effective control possible that has the lowest collateral impact to the environment. Table E-1 identifies the effectiveness of potential controls for selected invasive plant species found on the Argonne site.

Mechanical control is the alteration of the physical structure of an organism. An example is the removal of the large parts, limbs, and branches of an autumn olive shrub and either grinding the stump or applying an herbicide to the remaining parts to control the specimen. Biologic control is the utilization of a living predator or pathogen to control a problem species. In most cases, it is the use of a control of an invasive species from its origin that does not occur in the new range. Purple loosestrife can be controlled by use of a beetle species that consumes parts of the plants and thereby reduces the plant’s expansion. Herbivory is a mechanical and biologic control that is distinct enough to warrant elevation to a unique control. It is the utilization of animal herds to control invasive species. In most instances it is conditionally effective, but can be useful where an invasive has within its natural history herbivory as a control of its range.

Prescribed fire is the burning of natural fuels to control invasive plant species that are not adapted to fire. The tool is very effective on species that invade habitats with a history of fire in their development. Most habitats within the Chicago region have a frequency of fire occurrence over millennia that influenced their species composition and resilience to fire. Therefore,

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

prescribed fire (controlled burning) can be effective for invasive species control, without harm to habitats.

Invasive species become costly problems in the absence of identification, assessment, and action as demonstrated by the significant and increasing number and populations of invasive species. No action, as a control alternative, has therefore demonstrated its impact. The National Environmental Policy Act charges all federal agencies to consider no action as an alternative so as to determine if an action has a greater unintended adverse impact to the environment. Overall, no action will result in an ever-more-costly impact on the environment; however, each control option may have to be evaluated at the individual project level – location, characteristics, and invasive species present to determine the best control option.

**TABLE E-1 Control of Invasive Plant Species at the Argonne Site**

Control Matrix	Argonne Site Significance					Control Options							
	Not Present	Not significant	Population stable (+/-)	Significant and Expanding	Throughout	Ranked – 1 -Most Effective, 2 – Conditionally Effective, 3 – Not Effective						Notes	
Chemical						Mechanical	Biologic	Fire	Herbivory	No Action			
Species													
Plants													
ALKALI GRASS				√									
ALSIKE CLOVER				√									
AMUR CORK TREE		√											
AMUR HONEYSUCKLE				√									
AMUR MAPLE		√											
ANNUAL BLUE GRASS		√											
APPLE		√											
ASPARAGUS		√											
AUSTRIAN PINE		√											
AUTUMN OLIVE		√				1	2	3	2	2	3		
BEGINNER'S PONDWEED		√											
BIRD'S FOOT TREFOIL				√									
BITTER DOCK		√											
BITTERSWEET NIGHTSHADE			√										
BLACK BINDWEED			√										
BLACK LOCUST				√		1	1	3	2	3	3		
BLACK MEDICK			√										
BLACK MUSTARD			√										
BLACK SWALLOWWORT		√											
BLADDER CAMPION		√											
BORDER PRIVET		√											
BOUNCING BET		√											
BRISTLY FOXTAIL		√											

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Control Matrix	Argonne Site Significance				Control Options								
BROOM-CORN MILLET	√												
BROWN KNAPWEED	√												
BULL THISTLE		x											
BURNING BUSH			x										
BUTTER-AND-EGGS	x												
BUTTERWEED	x												
CANADA BLUE GRASS			x										
CARPET WEED	x												
CATNIP		x											
CHICORY				x									
CHINESE CUP GRASS	x												
COCKLEBUR		x											
COMMON BUCKTHORN		√		√	1	2	3	1*	2	3	*Effective on seedlings		
COMMON BURDOCK		x											
COMMON CHICKWEED		x											
COMMON COMFREY	x												
COMMON DANDELION				x									
COMMON DAY FLOWER	x												
COMMON FLAX	x												
COMMON FLY HONEYSUCKLE			x										
COMMON GOAT'S BEARD	x												
COMMON GROUNDSEL	x												
COMMON KNOTWEED		x											
COMMON MALLOW	x												
COMMON MULLEIN		x											
COMMON ORACH		x											
COMMON PLANTAIN		x											
COMMON PRIVET			x										
COMMON SOW THISTLE		x	x										
COMMON ST. JOHN'S WORT		x											
CORALBERRY			x										
CORN	x												
CORN SPEEDWELL	x												
CRACK WILLOW	x												
CREEPING CHARLIE		x											
CREEPING SMARTWEED		x											
CROWN VETCH			√		1	2	3	2*	2	3	*useful to burn off duff		
CURLY DOCK		x											
CUT-LEAVED TEASEL			x		2	1	3	3	3	3	2 species in area		
DAFFODIL	x												
DAHURIAN BUCKTHORN	x												
DAME'S ROCKET		√+			1	1*	2	1	2	3	*for basal rosettes		
DEPTFORD PINK	x												
DOG FENNEL	x												
DOG ROSE	x												
DOWNY BROME			x										

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Control Matrix	Argonne Site Significance				Control Options							
DUTCH MICE	x											
EARLY SPIREA	x											
ENGLISH PLANTAIN				x								
EUROPEAN Highbush CRANBERRY		x										
EUROPEAN SPINDLE TREE	x											
EUROPEAN WATER MILFOIL	x											
EXPRESSWAY ASTER			x									
FALSE REDTOP	x											
FIELD BINDWEED		x										
FIELD CRESS		x										
FIELD HAWKWEED		x										
FIELD SORREL	x											
FIELD THISTLE			x									
FLOWER-OF-AN-HOUR	x											
FRINGE TREE	x											
GARDEN SUNFLOWER	x											
GARLIC MUSTARD			√		2	1*	3	1	3	3		*for basal rosettes
GIANT FOXTAIL		x										
GIANT GREEN FOXTAIL	x											
GLOSSY BUCKTHORN			x									
GREAT BURDOCK		x										
GREEN FOXTAIL		x										
HAIRY CRAB GRASS	x											
HAIRY WILLOW HERB	x											
HARDY CATALPA			x									
HELLEBORINE ORCHID	x											
HORSE NETTLE		x										
HUNGARIAN BROME				x								
INDIAN STRAWBERRY	x											
ITALIAN RYE GRASS	x											
JAPANESE BARBERRY			x									
JAPANESE CHESSE			x									
JAPANESE CRAB		x	x									
JAPANESE HEDGE PARSLEY	x											
JAPANESE HONEYSUCKLE			√		2	2	3	3	2	3		
KENTUCKY BLUE GRASS		√			1	3		3	3	3		
LADY'S THUMB		x										
LAMB'S QUARTERS		x										
LESSER SALT SPURRY	x											
LILY-OF-THE-VALLEY			x									
LITTLE-LEAVED LINDEN	x											
LIVE-FOREVER	x											
MAXIMILIAN SUNFLOWER	x											
MEADOW FOXTAIL		x										
MONEYWORT		√+			1	3	3	2	3	3		

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

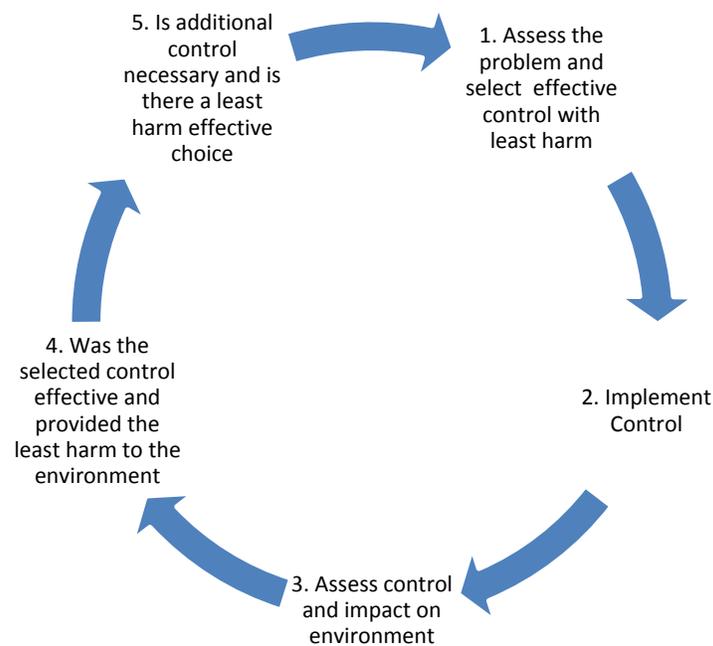
Control Matrix	Argonne Site Significance				Control Options						
MOTHERWORT			x								
MOUSE-EAR CHICKWEED			x								
MUGWORT				x							
MULTIFLORA ROSE			√+		1	2	3	2*	3	3	*Effective on seedlings
MUSK THISTLE		√			1	2	2	2	3	3	
NORWAY MAPLE			X								
OATS		x									
ORANGE DAY LILY			x								
ORCHARD GRASS			√	√	1	3	3	3	3	3	
ORIENTAL BITTERSWEET				√	1	2	3	2*	3	3	*Effective on seedlings
ORNAMENTAL PEAR				x							
OSAGE ORANGE			√		1	1	3	2	2	3	
OX-EYE DAISY				x							
PENNY CRESS			x								
PERENNIAL RYE GRASS		x									
PINEAPPLE WEED		x									
PRICKLY LETTUCE			x								
PURPLE LOOSESTRIFE				x							
PURSLANE		x									
QUACK GRASS			x								
QUEEN ANNE'S LACE				x							
RED CLOVER			x								
REDTOP			x								
REED CANARY GRASS				x							
ROUGH BLUE GRASS		x									
ROUGH DROPSEED		x									
SALT SPURREY		x									
SALT-MEADOW GRASS			x								
SEA BLITE		x									
SEASIDE GOLDENROD				x							
SHEEP FESCUE		x									
SHOWY CENTAURY		x									
SHOWY FLY HONEYSUCKLE		x									
SIBERIAN CRAB		x									
SIBERIAN ELM				x							
SIDEWALK KNOTWEED		x									
SMALL SNAPDRAGON		x									
SMOOTH ARROW-WOOD				x							
SMOOTH CRAB GRASS			x								
SORGHUM		x									
SPEARMINT		x									
SPINY SOW THISTLE			x								
SQUIRREL-TAIL GRASS				x							
STORE-FRONT SOW THISTLE		x									
SWEET GUM				x							
SWEET WORMWOOD		x									

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020

Control Matrix	Argonne Site Significance				Control Options					
SWEETBRIER	x									
TALL BUTTERCUP	x									
TALL FESCUE		√+			1	2	2	3	2	3
TALL YELLOW IRIS	x									
THYME-LEAVED SANDWORT	x									
THYME-LEAVED SPEEDWELL	x									
TIMOTHY		x								
TOOTHED SPURGE	x									
TREE OF HEAVEN			x							
TRUMPET CREEPER	x									
TUMBLEWEED	x									
TURNIP	x									
TURQUOISE BERRY	x									
UPRIGHT CINQUEFOIL		x								
VELVETLEAF		x								
WASHINGTON HAWTHORN	x									
WATER CHICKWEED	x									
WAYFARING TREE	x									
WHEAT	x									
WHITE CAMPION	x									
WHITE CLOVER		x								
WHITE MULBERRY		x	x							
WHITE MUSTARD	x									
WHITE POPLAR	x									
WHITE SWEET CLOVER		x	x							
WHITE WILLOW	x									
WILD FOUR O'CLOCK	x									
WILD PARSNIP			x							
WILLOW LETTUCE		x								
WISTERIA	x									
WOOD BLUE GRASS	x									
YARROW		x								
YELLOW FOXTAIL		x								
YELLOW ROCKET		x								
YELLOW SWEET CLOVER		x	x							
YERBA DE TAJO	x									

## Adaptive Management and Integrated Pest Management

We learn from process application and results information that enables refinement of processes that increase effectiveness and efficiency and protect against accidents and catastrophe. Adaptive management (Figure E-1) applied to invasive species problems can be very effective. We have a substantial amount of information about invasive species and effective control techniques (as in Table E-1); however, with every new invasive species and increasing costs, new and improved methods are vital to an improved control operation.



**FIGURE E-1 Invasive Species Adaptive Management.**

# NATURAL RESOURCES MANAGEMENT PLAN, 2018–2020