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Oak Ridge National Laboratory

Environmental Landscape Design Associates

Sustainable Landscapes Initiative 2020

Leah Gardner, Sam Rogers, and James L. Sipes

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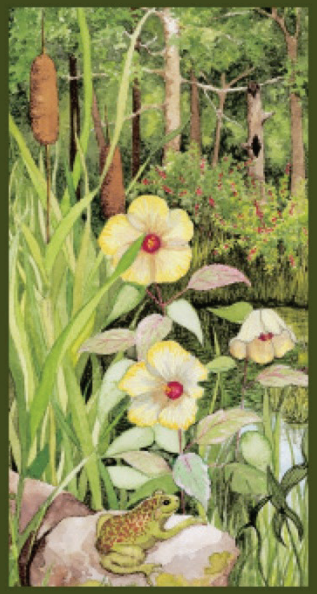

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ACKNOWLEDGMENTS

Environmental Landscape Design Associates is a small landscape architecture practice with idealistic visions for the role landscape can play in improving and restoring our environment while providing visual amenity and wellness. We have been inspired by the emerging attention to creative ideas that address present, past, and future issues relating to sustainability. Our association with Oak Ridge National Laboratory prompts us to hope that ORNL can serve as a national model to demonstrate developing and retrofitting a 'blue-green' fabric of campus landscape that contributes to energy solutions, wellness, water quality, natural resource conservation, and respect for the sense of place. It is difficult to imagine any other government or private installation offering such a unique transformative opportunity.

We would like to acknowledge the role of the ORNL Landscape Committee for initiating and supporting this report, and we especially thank Pat Parr and Michael Ryon for their extraordinary commitment and inspiration for many years of service in leading the way. We also acknowledge the impressive work of University of Tennessee landscape architecture student interns David Dalton and Wyn Miller, who have compiled and shared summaries of their 2010 and 2011 summer work experiences at ORNL relating to ecological landscape analyses, design, and management.

Finally, we appreciate the opportunity to collaborate with James L. Sipes, ASLA, who has been significantly involved in the study and report. Jim has gained a national reputation as an author and practitioner in the mainstream of dialog and practice relating to design and planning issues in sustainability. He is author of *Sustainable Solutions for Water Resources* and is a contributing editor for *Landscape Architecture Magazine*.

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1. INTRODUCTION

The goal of the Oak Ridge National Laboratory (ORNL) Sustainable Landscapes Initiative 2020 is to provide a framework that guides future environmental resources and sustainable landscape practices on the ORNL campus.

This is an update of the 2003 report *Oak Ridge National Laboratory Conceptual Landscape Plan and Design Guidelines* prepared by Hawkins Partners, Inc., Landscape Architects. The 2003 report has been a significant contribution to defining a direction for the past several years, and the document should still be regarded as a valuable resource manual. Thus, the intent of the Sustainable Landscapes Initiative 2020 is to provide supplementary information that does not replicate or contradict the previous work. This update is presented in the context of embracing new opportunities and in the spirit of constructive critique of past projects relating to the campus landscape.

1.1 PHILOSOPHY, MINDSET, AND ETHIC

Landscape is a holistic concept relating to our surrounding environment. Too often it is seen as a process of some kind of optional cosmetic treatment, which often falls far short of its true potential. In the context of a campus of a major national laboratory, the landscape should exemplify not only visual appeal, but true ecological and scientific values not always associated with the term landscape. It is recommended that the understanding of the term be elevated if the next decade of landscape visioning is to be meaningful, valuable, and directed on a path toward sustainability. Thus, this document seeks to express the deeper values associated with landscape as amenity, ecological service, research value, and educational interpretation.

The scientific innovation of Oak Ridge National Laboratory (ORNL) is world renowned and indisputable. However, to analyze the 'landscape' issues of the ORNL campus is to experience the extreme in conditions. From the bleak post-war 'rad' zones covered with rip-rap and the lawn dominant landscapes reminiscent of the 1950's and 1960's is emerging a landscape that is moving in the progressive direction of restoring the land and water. Visible now is the integration of more biodiversity, riparian conservation, and the eye appealing colors and textures of native plants in the campus landscape strategy. Much credit is due to the proactive involvement of ecologists serving on the ORNL Landscape Committee who have recognized this stewardship responsibility and opportunity.

This paradigm shift is a major philosophical change and will not be without its challenges. What is ecologically sound is often not the easiest or most expedient process in landscape planning or landscape management. This adds credence to why ORNL should be pursuing goals of 'sustainable' landscapes, not rooted in style or visual preference, but rooted in an environmental ethic. Therefore, future landscape projects at ORNL could lead the way in resolving this universal dilemma of expedient, decorative landscapes versus 'environmental' landscapes that reach deeper in form and function. In meeting this challenge, 'messy' and sometimes rough renditions of these new landscapes could be presented with a high standard of aesthetic appeal, not always easy, but doable through artful planning of environmental designers and vigilant care by knowledgeable maintenance and management personnel.

Probably the greatest justification of pursuing the 'environmental' landscape paradigm is the surrounding Oak Ridge Reservation (ORR). This reservation of 35,000 acres is a nationally significant natural area designated as a unit of the Southern Appalachian Biosphere Reserve and is the only representative of the Ridge and Valley physiographic province in the international United Nations Educational, Scientific, and Cultural Organization (UNESCO) Man and Biosphere Program (Parr and Mann 1995). Thus, an opportunity exists to better integrate the ORNL campus into the surrounding ORR resource, which may now seem disconnected by most. With so many scientists visiting and working at ORNL, this is an obvious connection that could be made stronger.

ORNL has established an environmental policy that helps guide decisions made on campus. The ORNL Environmental Policy states:

- We are committed to complying with legal, contractual, and other applicable requirements
- We are committed to operating in a manner that protects and restores the environment and to integrating pollution prevention into planning and decision-making
- We are committed to providing and continually improving research, services, products, and management systems of the highest quality consistent with the needs, expectations, and resources of our customers
- We are committed to communicating appropriate environmental management system information to staff, subcontractor personnel, customers, and other stakeholders

1.2 DESIGN PROCESS

The design process is intended to outline the steps needed to ensure that a project has clearly defined objectives, that sufficient analysis is conducted, and that design decisions take into account all considerations in order to lead to a sustainable solution. An effective design process should lead to better design and planning decisions for the ORNL campus. There are many different approaches to the planning and design process, but they can all be simplified into five major steps.

- Research. Define what the project will be.
- Inventory/Analysis. Determine if the site will support the proposed use.
- Synthesis. Develop a concept and design for the site
- Implementation. Install the project
- Evaluation. Determine if the project functions as intended

Knowing where one is in the process will influence the scale of thinking, the type of data that required, and the application use to process the data.

1.2.1 Research

One of the initial steps in the design process is to determine what the project is and how best to approach a specific site or issue. This involves understanding the issues involved, and opportunities and concerns that need to be addressed. For the ORNL campus, it is recommended that this

research look at previous uses that may have impacted a site. For a project to meet its stated goals, it should to be considered within a broader context. This involves understanding local and regional trends and patterns and the changes that are expected to occur, both on the ORNL campus and with adjacent developments. The ORNL Landscape Committee could help define the goals, objects, and parameters of each landscape project.

1.2.2 Inventory/Analysis

Effective strategic planning always begins with a sound base of information. For every project, designs conduct an initial inventory and analysis of the site and adjacent areas, and this information serves as the foundation from which decisions are made. Designers use geospatial data, satellite photos, computer-assisted design data, and site visits to identify key existing conditions and opportunities. The process includes documenting existing facilities and amenities, thoroughly analyzing the implications of the existing site, and then starting the synthesis process to determine the most appropriate design and planning decisions. The inventory phase includes identifying all significant cultural, natural, historic, and aesthetic resources and evaluating them as part of the planning process. Soil contaminants, radiation, or other chemicals that may have impacted a site should be identified at the start of any design or construction project.

Part of understanding local needs is to listen to key stakeholders. This includes members of the ORNL Landscape Committee as well as users that may be impacted by a particular development. While accurate facts are essential, it is the public's vision, trust, and support that truly drive the effort. Stakeholder involvement will be paramount in generating enthusiasm and building the broad community support for innovative designs.

1.2.3 Synthesis

Synthesis involves building on the research and inventory/analysis and generating a plan that meets the stated goals of a project. Design concepts could be drawn from a thorough and careful process that determines the best solution for a given problem. Conceptual plans compare and contrast a site's existing characteristics with identified needs, preferences, and associated service requirements. Emphasis is on designs that are sustainable and support the long-term vision of the ORNL campus.

The plan evaluates potential sites on a property and determines the best location for specific program elements. Based on a review of the alternative concepts, feedback from ORNL stakeholders is incorporated into the design. The result of this process is the development of a final site plan, which may be one of the original alternative concepts or some new concept that perhaps has elements of each.

1.2.4 Implementation

The final measure of any plan is whether it is implemented. The objective is to develop a plan that is achievable and sustainable. The key is to develop plans that use locally available materials, are clear and understandable so there are no misunderstandings, and can be installed using the current base of knowledge. It is important to have contractors that understand how to install native plant materials and other hardscape and softscape elements, and to do so at an appropriate time of year. Landscape projects are best installed during the spring or fall in order to minimize

impacts to plant material. Once a project is installed, the project could be monitored closely to ensure the health of the plant material and the overall success of the project.

1.3 ORNL LANDSCAPE COMMITTEE

The ORNL Landscape Committee is responsible for the following:

- Planning, reviewing, and approving proposed landscape/hardscape plans within the ORNL site
- Evaluating various options to ensure elimination of duplication of effort, use of cost effective approaches, protection of the environment, compliance with regulations, inclusion of aesthetic appeal, and implementation of new ideas
- Communicating funding needs to the Director of F&O Facilities
- Integration of wellness, engineering, project planning, and natural resources management aspects into Landscape planning

2. ORNL PLANS & OTHER INITIATIVES

In 2000, ORNL developed a 10-year plan to modernize the lab's facilities. Many of the ideas in that original plan have been implemented and the results have had a major impact on the overall character of the campus. Additional changes are planned, and these are being guided by two major campus plans: (1) Oak Ridge National Laboratory Conceptual Landscape Plan and Design Guidelines (2003); and (2) ORNL Campus Master Plan (Draft 2010). In addition, two other documents have influenced the ORNL Sustainable Landscapes Initiative 2020 plan. They are: (1) The Sustainable Sites Initiative (SITES); and (2) USGBC Roadmap to Green Campus.

Fig. 1. An interpretive sign recently developed and installed at the HTML building on ORNL Campus.

(Design and illustrations, Environmental Landscape Design Associates)

2.1 THE SUSTAINABLE LANDSCAPES INITIATIVE

The ORNL Sustainable Landscapes Initiative (SLI) 2020 builds upon the objectives and guidelines established in these other documents and applies them to the ORNL campus. The SLI Initiative 2020 plan formalizes and extends concepts that are currently being developed on the ORNL campus as part of ORNL's 'Sustainable Campus Initiative,' which is already being branded and promoted for the ORNL campus. Some of these concepts are already being applied in the interpretive signage that has been developed for a couple of ORNL landscape projects (Fig. 1).

Recommendations in the ORNL Sustainable Landscapes Initiative 2020 plan illustrate concepts that respect and build upon the sense of place both visually and ecologically. Emphasis is on plant communities and habitat restoration, as well as the integration of a native plant palette. To reflect the ecological diversity of the setting, concepts include restored stream buffers, rain gardens, bio-swales, pocket woodlands, pocket wetlands, and even pocket barrens. To serve the interface with the built environment, green screens, ledge gardens, green roofs, green walls, environmental pavers, and recycled landscape materials are explored.

Many areas on campus provide opportunities for both

environmental and visual landscape improvement; and, priorities are suggested. There are also opportunities for accommodating or improving pedestrian/bicycle circulation and associated outdoor open spaces, sitting areas, courtyards, etc. as well as educational signage associated with the initiative.

In order to accomplish a comprehensive update, the ORNL Sustainable Landscapes Initiative 2020 plan follows two tracks – one track associated with long-range, visionary plans, and the other track associated with related demonstration projects that are feasible in the short term. Some of the current demonstration projects already underway include the First Creek riparian restoration, HTML landscape project, and White Oak and First Creek 'STEM' zones.

2.2 2003 ORNL CONCEPTUAL LANDSCAPE PLAN AND DESIGN GUIDELINES

The 2003 *Oak Ridge National Laboratory Conceptual Landscape Plan & Design Guidelines* established a unified vision for future landscape improvements and provided a framework for fulfilling the goals of the plan. The plan states that "the ORNL landscape should be maintained in a way that respects the natural tendencies of the landscape, protects and maximizes ORNL's investment, and insures that the landscape successfully fulfills its intended role" (Fig. 2).

Fig. 2. Some examples of existing landscape spaces on ORNL campus.

The goals and objectives developed in the 2003 Conceptual Landscape Plan & Design Guidelines include:

- GOAL 1: The landscape should create a cohesive campus that supports the identity of ORNL and the region while recognizing unique areas of the campus.
- GOAL 2: The landscape should facilitate navigation of the campus.
- GOAL 3: The landscape should inspire and reflect the mission and aspirations of ORNL.
- GOAL 4: The landscape should require low energy use and minimal intervention

- GOAL 5: The landscape should stand the test of time and continue to enhance the campus in the future. The landscape should meet the needs of the campus while not comprising the ability for the campus to meet its future needs.
- GOAL 6: The landscape should reinforce the environmental goals of ORNL
- GOAL 7: The landscape should provide cost effective solutions for the needs of the campus.
- GOAL 8: The landscape should be a working laboratory.

The landscape design guidelines portion of this plan includes the following in order to meet the goals of the plan:

- Appropriate Use of Plant Species
- Planting and Seeding Techniques
- Planting and Seeding Schedules
- Landscape Management Principles
- Landscape Lighting Principles

Most of the goals, objectives, and design guidelines defined in the 2003 *Conceptual Landscape Plan & Design Guidelines* are still applicable. These were used as building blocks for this report.

The 2003 plan by Hawkins Partners, Inc. was a significant step towards organizing goals and objectives and articulating a 'unified vision'. The ORNL Sustainable Landscapes Initiative 2020 is intended to update and build on this work by offering retrospective comments and further guidance.

2.3 ORNL CAMPUS MASTER PLAN (DRAFT 2010)

In 2010, Flad Architects and Barge Wagoner Sumner & Cannon were contracted to develop a long range master plan for ORNL's main campus. The purpose of the 2010 ORNL Campus Master Plan is to guide the redevelopment and expansion of the main ORNL campus over the next twenty years. The master plan also makes general recommendations related to the character of both the landscape and architectural expression of the new campus environment. Integral to this is the concept of sustainability. That includes reducing energy use, reducing carbon footprint, and water conservation.

The plan establishes major development zones and defines appropriate uses for each major development site. The plan also provides a phased approach to developing specific areas of the site. This type of prioritization is necessary to allow the development on an integrated research community in a timely manner.

The four main messages of the master plan are:

- Decisions related to future building placement should be focused, to the extent possible, on locating functional uses in close proximity to existing programs of similar nature within a common directorate.

- Future development should occur in a planned fashion, focusing on the transformation of the central campus along Central Avenue. The placement of the Transportation Hub, Amenities, and Educational/ Training facilities along this corridor will energize the development.

- The master plan should drive the prioritization of the EM clean-up activities and other enabling projects in the primary development zones to assure land availability when a program need arises.

- Sustainability should be a key consideration in all development decisions.

The ORNL Campus Master Plan only briefly touches on landscaping and natural resources on campus with recommendations regarding water management and the use of native materials and plants in a 'park-like setting.

2.4 THE SUSTAINABLE SITES INITIATIVE

The Sustainable Sites Initiative (SITES) is a set of voluntary national guidelines and performance benchmarks for sustainable land design, construction and maintenance practices. It was developed through an interdisciplinary effort by the American Society of Landscape Architects, the Lady Bird Johnson Wildflower Center at The University of Texas at Austin and the United States Botanic Garden. SITES is the first national rating system for sustainable landscapes and is intended to transform land development and management practices.

SITES is similar to the Green Building Council's LEED (Leadership in Energy and Environmental Design) green building certification and rating system. LEED is geared specifically for residential and commercial buildings, but there is also a rating system called LEED for Neighborhood Development (LEED-ND). LEED-ND focuses on location and community pattern while SITES focuses on site scale projects. Although the two rating systems are very different, they are intended to be complementary.

The SITES rating system assesses specific site performance on a 250-point scale, with points awarded based on credits for the following areas:

- The use of materials
- Restoration of soils and vegetation
- Sustainable practices in construction and maintenance

The prerequisites and credits in SITES are organized into nine sections and are based on the site development process.

- Site Selection
- Pre-Design Assessment and Planning

- Site Design—Water
- Site Design—Soil and Vegetation
- Site Design—Materials Selection
- Site Design—Human Health and Well-Being
- Construction
- Operations and Maintenance
- Monitoring and Innovation

To achieve sustainability, a project must be: (1) socially equitable; (2) economically feasible; and (3) environmentally sound. SITES established a set of Guiding Principles of a Sustainable Site that focuses on the environment, including those aspects of economic feasibility and social equity that intersect with the environment. These guiding principles are:

- Do no harm - Make no changes to the site that will degrade the surrounding environment. Promote projects on sites where previous disturbance or development presents an opportunity to regenerate ecosystem services through sustainable design.

- Precautionary principle - Be cautious in making decisions that could create risk to human and environmental health. Some actions can cause irreversible damage. Examine a full range of alternatives— including no action—and be open to contributions from all affected parties.

- Design with nature and culture - Create and implement designs that are responsive to economic, environmental, and cultural conditions with respect to the local, regional, and global context.

- Use a decision-making hierarchy of preservation, conservation, and regeneration - Maximize and mimic the benefits of ecosystem services by preserving existing environmental features, conserving resources in a sustainable manner, and regenerating lost or damaged ecosystem services.

- Provide regenerative systems as intergenerational equity - Provide future generations with a sustainable environment supported by regenerative systems and endowed with regenerative resources.

- Support a living process - Continuously re-evaluate assumptions and values and adapt to demographic and environmental change.

- Use a systems thinking approach - Understand and value the relationships in an ecosystem and use an approach that reflects and sustains ecosystem services; re-establish the integral and essential relationship between natural processes and human activity.

- Use a collaborative and ethical approach - Encourage direct and open communication among colleagues, clients, manufacturers, and users to link long-term sustainability with ethical responsibility.

- Maintain integrity in leadership and research - Implement transparent and participatory leadership, develop research with technical rigor, and communicate new findings in a clear, consistent, and timely manner.

- Foster environmental stewardship - In all aspects of land development and management, foster an ethic of environmental stewardship—an understanding that responsible management of healthy ecosystems improves the quality of life for present and future generations.

By following the SITES rating system, ORNL would be able to quantify and qualify efforts being made toward creating a sustainable campus. The guiding principles of SITES are consistent with the sustainability principles recommended for ORNL.

Fig. 3. Staff are provided with bikes as part of ORNL's green transportation initiative.

2.5 USGBC ROADMAP TO GREEN CAMPUS

The U.S. Green Building Council (USGBC) is promoting the idea of a green campus, which focuses on "improving energy efficiency, conserving resources and enhancing environmental quality by educating for sustainability and creating healthy living and learning environments." The success of a green campus is dependent on an integrated approach to planning and implementing sustainability initiatives (Fig. 3).

The USGBC created Roadmap to a Green Campus, which offers a strategy for using the LEED green building certification program as a framework for developing campus-wide sustainability plans. This Sustainable Landscapes Initiative document also offers strategies that ORNL can use on their journey to institute sustainable landscape practices that reflect the unique needs and attributes of the ORNL campus (Fig. 4).

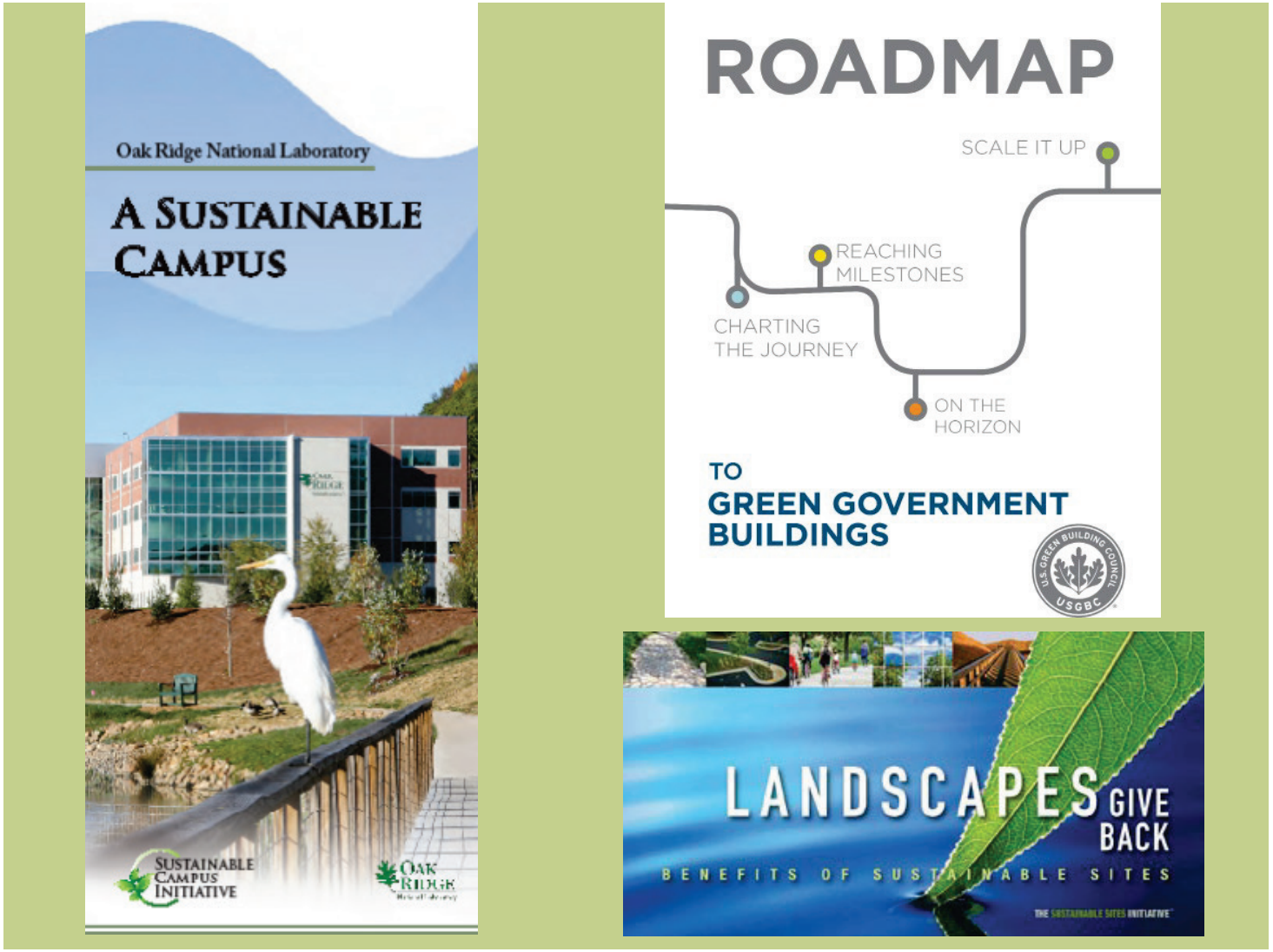


Fig. 4. Examples of brochures promoting sustainability on the ORNL website, www.sustainablesites.org, and www.usgbc.org.

3. ENVIRONMENTAL SETTING

The Oak Ridge National Laboratory is located on almost 3,000 acres within the Oak Ridge Reservation in Melton and Bethel Valleys, approximately 10 miles southwest of downtown Oak Ridge, Tennessee. The unique setting of the surrounding landscape defines the overall character of the campus. This environmental setting serves as the inspiration for this master plan.

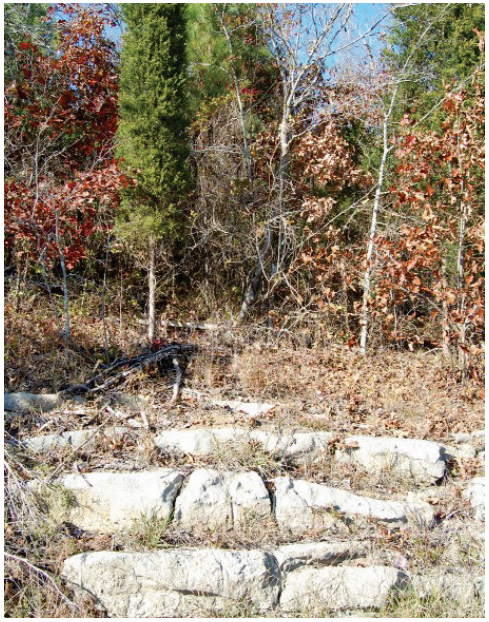
The 2003 plan categorized areas of the campus into three broad habitats:

- Ridge
- Riparian
- Valley

In general, plant communities are found in specific habitats where growing conditions are favorable, and these three habitats have their own unique characteristics in terms of topography and hydrology. On the ORNL campus, however, all three are significantly impacted by human activities.

3.1 PHYSIOGRAPHY

The main campus of Oak Ridge National Lab is situated in Bethel Valley, nestled between two ridges known locally as Chestnut Ridge and Haw Ridge. To broaden the physiographic context; however, it is appropriate to consider the Oak Ridge Reservation (ORR) comprised of approximately 35,000 acres (55 square miles) surrounding the central campus The ORR exemplifies the typical Valley and Ridge Physiographic Province as a snapshot in time, now significantly conserved though also impacted by both historical and contemporary development.



Photograph by R.K. McConathy

Fig. 5. Limestone rock outcrops on the Oak Ridge Reservation.

The valleys in the vicinity are underlain by bedrock dominated by siltstones and limestones, which may vary from shale to shaly and silty limestone (Fig. 5). The ridges are more erosion resistant and are predominantly sandstones, siliceous shales, and dolostones. Karst features are

common and subsurface drainage is significant. Soils of the ravines and valleys are an assortment of alluvium that may vary from wet or boggy to well drained. The soils of the ridges vary from deep and cherty to shallow and rocky.

Vivid descriptions of some of the unique natural areas are included in a 2009 report by Michael J. Baranski titled *Natural Areas Analysis and Evaluation: Oak Ridge Reservation*. Following are some of the descriptive terms by Baranski that help visualize the physiography:

- 'Steep Rocky Slopes'
- 'Limestone Rock Outcrops'
- 'River Bluffs'
- 'Rocky Ridge with Sinks'
- 'Shaly Cliffs'
- 'Limestone Cliffs'
- 'Steep Slopes'
- 'Dry Rocky Woods'
- 'Caves'
- 'Springs'
- 'Forested Wetlands'
- 'Groundwater Seeps'
- 'Barrens'
- 'Ephemeral Pond'
- 'Wet Meadow'
- 'Sinking Creek'
- 'Forested Slopes'
- 'Small Ravine'

The basic physiography (or geomorphology) of the valleys and ridges, in essence, establishes the terrain for the other components that collectively comprise the environmental setting. The hydrology, plant communities, and biodiversity are some of the more important landscape features that are greatly influenced by the terrain, and they are also interrelated with the other.

3.2 HYDROLOGY

The natural (and /or modified) drainage, both surface and subsurface, comprise the hydrology. Observing and understanding the inherent hydrology of a place can be beneficial in sustainable landscape planning (Fig. 6). As the geology, soils, topography, and land cover may influence overall watershed planning, these same factors can be applied to more limited areas impacted by development. There is wide diversity within the ORR in hydrologic features. For example, underlying geology in steep shaly areas with shallow soils may contribute to high runoff potential. In contrast, deep, cherty soils in Karst limestone areas may infiltrate more water, leading to less runoff and greater likelihood of subsurface drainage

patterns, springs, and seeps. Forested areas and other areas of 'rough' vegetation can also slow and filter runoff, leading to positive effects on water quality and reduced impacts of flash flooding. While there is general emphasis on permanent streams as indicators of water quality, one should especially consider the minor drainage features in any watershed such as swales and ravines, bogs and wetlands, and wet weather conveyances as important stewardship mechanisms for a healthy watershed.

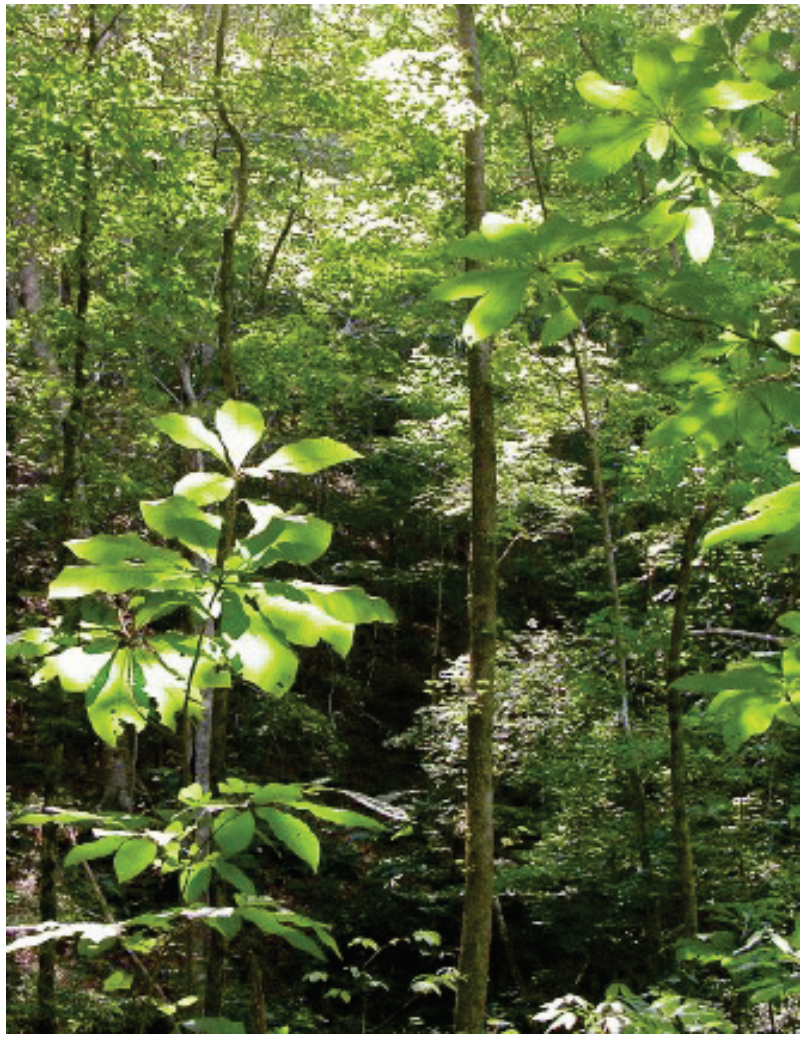
White Oak Creek is the major surface drainage feature within the ORNL campus, and there are several named tributaries such as First Creek. Not so obvious is the disruption in the hydrology by roads, buildings, parking areas and related campus development. Impervious pavements, roofs, piped drainage, and even lawns can greatly increase runoff quantity and lessen the filtration opportunities provided by percolation. Thus, the challenge in campus hydrology is to mitigate past and future development impacts and to mimic natural principles and processes as much as practical. Such an approach can be a significant part of the collective sustainable campus strategy.

Photograph by R.K. McConathy

Fig. 6. Understanding natural hydrology benefits sustainable landscape planning.

3.3 PLANT COMMUNITIES

Plant communities consist of fairly predictable associations of individual plant species that tend to occupy a particular ecological niche in the landscape. They can be special indicators of the composite site and environmental conditions (Fig. 7). Thus, soils, moisture regime, sun and shade factors, disturbance factors, and microclimate nourish and favor certain species. While the



Photograph by R.K. McConathy

Fig. 7. A mesic plant community on the Oak Ridge Reservation.

general determinants of climate and geology influence the formation of broad plant community patterns in the landscape the site specific factors are mainly:

- Topography and topographic position
- Aspect/Shade/Exposure to Sun
- Soils (especially pH)
- Hydrologic and Drainage Factors (surface and subsurface)
- Moisture Regime (mesic, sub-mesic, xeric, sub-xeric, hydric, etc.)
- Microclimate

In landscape design and planning, understanding the contextual plant communities surrounding a site is of paramount importance in providing an ecological basis for 'sustainable' approaches to design. Thus, the plant communities of the ORR become the most logical prototypes to help form the primary plant palette for landscape projects within the ORNL campus complex. While a secondary palette may be considered from plant communities of the region, there is good justification to look first in the locale for adapted species.

According to extensive ecological documentation, the plant communities of the ORR are interesting and wide ranging in their diversity. Over 1100 different species have been inventoried as compared to approximately 1650 species within the Great Smoky Mountains National Park (Parr and Hughes 2006). While there are many rare plants that may be found within the ORR data base, understanding the typical plant communities may be more applicable in forming a basis for landscape use.

Wooded slopes of Oak-Hickory forest provide an abundance of native plant diversity, and these forests have now reached a maturity of outstanding importance, with multiple layers represented. Additionally, drier sites may consist of Oak-Pine or Pine-Oak composition. Several mesophytic forest areas are also represented as well as hydric or wetland

marshes and swamps. Especially interesting are the uncommon cedar barrens that occupy thin, dry soils. These unique ecosystems are comprised of native grasses and wildflowers surrounded by Eastern red cedar and other drought tolerant trees and shrubs in the edges (Figs. 8 and 9).

A listing by Michael J. Baranski in his 2009 report *Natural Areas Analysis and Evaluation: Oak Ridge Reservation* includes references to the following plant communities as a sampling:

- Old Growth Forest'
- 'Beech-Maple-Basswood' Forest
- 'Heath-Oak-Hickory-Tuliptree' Forest
- 'Floodplain Swamp'
- 'Riparian Wetland'
- 'Hemlock-Rhododendron' Area
- 'Red Maple-Sweetgum' Woodland'
- 'Xeric Hardwoods'
- 'Mesic Forest with White Pine – American Holly-Bottlebrush Buckeye'
- 'Cedar-Post Oak Barren'
- 'Beech-Mountain Laurel' Community
- 'Sphagnum-Fern' Wetland and Pools
- 'Fothergilla' Site
- 'Emergent and Scrub/Shrub Wetlands, and Canebreak'

Photograph by Pat Parr

Fig. 8. Edge habitat on the Oak Ridge Reservation.

To plant ecologists, these names conjure up imagery of great diversity and interesting associations of plants. From wetlands and shady, moist glens to open, dry barrens, the vicinity offers up a smorgasbord of inspiration and opportunity to the landscape designer or landscape architect seeking to connect the environmental setting with the ORNL campus landscape.

3.4 BIODIVERSITY

Margie Hunter, in her book, *Gardening with the Native Plants of Tennessee*, states, "A community in nature is a group of interacting plant and animal populations within a similar environment". This simple statement is important in reinforcing the concept of habitat, which is highly related to the plant communities of a given place. Add water or hydrology to the mix and even more complex and diverse ecological communities are expressed. This is often referred to as biodiversity.

The biodiversity of the ORR is well documented in numerous scientific reports. In addition to the diverse physiography, hydrology, and plant communities, the animal communities are highly significant. In their 2006 report titled *Oak Ridge Reservation Physical Characteristics and Natural Resources*, Patricia D. Parr and Joan F. Hughes summarize the animal species diversity as follows:

- ‘Over 70 species of fish’
- ‘About 45 species of reptiles and amphibians’
- ‘More than 200 species of resident, transient, and migratory birds’
- ‘More than 30 species of mammals’
- ‘Innumerable invertebrate species’

Parr and Hughes also emphasize the importance of ‘contiguous’ forests (many patches of 50 acres or more) within the 24,000 acres of forestlands of the ORR in providing special ‘interior’ habitat not often found elsewhere in the Valley and Ridge Physiographic Province or nationwide. Certain rare bird and wildlife species are dependent on this type of forest habitat. On the other hand, smaller forest patches, riparian zones, successional fields, barrens, and edges may also have great ecological value if properly managed. These are often more challenged by the occurrence of invasive exotic plant species, and these types of areas have significant application in the integration of ecology with horticulture in the ORNL campus landscape. ‘Ecological edges’, riparian buffers, ‘pocket wetlands’, ‘pocket woodlands’, ‘ledge gardens’, etc. , are some of the landscape strategies discussed later in this report that are intended to promote the integration of biodiversity as a key component of the ORNL ‘Sustainable Landscapes Initiative’.

Fig. 9. Clockwise from left: Rough Blazing Star, Cedar Barren plant community, Flowering Dogwood, Rusty Blackhaw, Rosinweed.

4. CULTURAL CONTEXT

Appreciation and understanding of how a rural valley in eastern Tennessee was transformed into the most prestigious scientific laboratory in the nation is important to remember in planning a sustainable future. This legacy presents many challenges and opportunities. Landscape development and restoration may provide both interpretation of the past and connection to the adjacent ridges and valleys.

4.1 HISTORIC SIGNIFICANCE

The Oak Ridge National Laboratory (ORNL) has a long and storied history that started in 1943 (Fig. 10), when it was established for the pilot-scale production and separation of plutonium for the World War II Manhattan Project. More than 3,000 workers constructed 150 buildings to create the core of the campus. Both the laboratory and the nearby city of Oak Ridge were built by the United States Army Corps of Engineers in less than a year on isolated farm land in East Tennessee. Oak Ridge housed more than 75,000 residents and workers within two years, and it has often been referred to as the 'secret city'.

Fig. 10. Historic marker on ORNL Campus.

The separation and production of uranium and plutonium for use in developing a nuclear weapon was conducted in four facilities: X-10, Y-12, K-25, and S-50. X-10 later became Clinton Laboratories, and then later the Oak Ridge National Laboratory. The X-10 reactor, also known as the Graphite Reactor, served as the model for reactors built at the Hanford Nuclear Facility in Washington State. The X-10 Graphite Reactor remains today in the central part of the ORNL campus, and it is listed on the National Register of Historic Places. In 1965 it was designated as a National Historic Landmark, based on the national and international significance of its contribution to science and technology.

The work at ORNL not only led to the development of the first atomic bomb, it also opened the doors to the atomic age.

After the end of the war, ORNL continued its isotope production and radioisotopes were shipped to research labs and medical centers throughout the nation. In the fifties, emphasis was on fission reactor development at ORNL. The lab's greatest impact on nuclear power during the 1950s came from reactor training.

In the 1950s and 1960s, work at ORNL shifted to peacetime research in medicine, biology, materials and physics. In the late 1970s, ORNL's mission broadened to include research in energy production, transmission and consumption. In the 21st century new cross-disciplinary programs in nanophase materials and computational sciences have been added to the research agenda.

There are several other sites within the Oak Ridge Reservation listed on the National Register of Historic Places. The most prominent within the campus vicinity is New Bethel Baptist Church and cemetery (Fig. 11). Built in 1924, the structure was spared demolition in 1942. It has since been maintained, occasionally has held 'homecomings', and now greets visitors entering from the east portal. The quaint church and cemetery serve as a reminder of the beauty and tranquility of Bethel Valley before the War era.

4.2 PRESENT IDENTITY

Today, ORNL is the U.S. Department of Energy's largest science and energy laboratory, having a staff of about 4,600 and an annual budget of more than $1.65 billion (Fig. 12).

The lab is well positioned to demonstrate leadership in science, engineering, and energy management and to further advance sustainability in federal operations and scientific research. ORNL's stated goal for innovation is to "help the Department maintain U.S. global leadership in science, engineering, and energy management. ORNL will continue to research, develop, demonstrate, and deploy innovative solutions and initiatives to advance sustainability."

Photograph by Wyn Miller

Fig. 11. New Bethel Baptist Church and cemetery.

In keeping with that goal, ORNL has invested more than $500 million of federal, state, and private funds over the past decade to create a more modern research environment. As part of the campus modernization effort, approximately 70 outdated facilities totaling more than 200,000 gross square feet have been demolished, and an additional 1,800,000 gross square feet is scheduled to be torn down. New facilities include the Advanced Materials Characterization Laboratory, the Center for Nanophase Materials Sciences, the Chemical and Materials Sciences Building, and state-funded joint institutes for computational sciences, biological sciences, and neutron sciences.

Fig. 12. ORNL is well positioned to demonstrate leadership in sustainability.

Space generated by demolition is expected to be used for both new buildings and restored natural areas or open space, designed to be sustainable components of a modern campus. ORNL plans on working towards LEED certification for all new buildings. Currently, six of the buildings on campus have received Leadership in Energy and Environmental Design (LEED) certification. Landscaping with native plants has been a major component of ORNL's modernization plan, and that is

expected to continue.

The ORNL Sustainable Landscapes Initiative 2020 should complement the laboratory's efforts to create a more energy efficiency campus. As researchers continue to evaluate potential savings from daylight harvesting, biofuels, window replacements, and ground-source heat pumps, the potential benefits of landscape plantings, green roofs, and natural filtering systems should also be considered.

In the solar-assisted charging station design, solar panels are installed in a canopy that covers the parking spaces (Figs. 13 and 14). Each station is equipped with a charger known as electric vehicle service equipment. The initial station on the ORNL campus is a prototype of the stations that are planned to be deployed regionally through 2012.

4.3 FUTURE IDENTITY

Recent commitments and attention toward a sustainable future for ORNL's campus undoubtedly will have far-reaching influence on the campus physical environment. This, in turn, can have a positive influence on the region and the nation.

Cleanup of lingering contaminated spaces and facilities will give way to outdoor amenities such as streetscapes, an energy efficient transit system, numerous outdoor gathering spaces, interconnected walking trails and greenways, and unified interpretation and wayfinding. In addition to the human interface, many ecological improvements will be gained including increased biodiversity, restored riparian zones, protected and enhanced woodland zones, and an overall reflection of the sense of place. From creative retrofits to environmentally sensitive new development, green infrastructure will permeate the campus and alternative energy systems will be showcased. On every level, a commitment to a sustainable future for ORNL could be evident.

Fig. 13. Solar-assisted charging stations on ORNL Campus.

Fig. 14. Existing Solar Panels on ORNL Campus.

5. LANDSCAPE CsHALLENGES AND OPPORTUNITIES

With Oak Ridge National Laboratory's setting, its mission, and its proclaimed commitment toward sustainability, all of the ingredients for leadership in restorative landscape development and management are in place. However, there are challenges and constraints associated with this unique opportunity for ORNL.

5.1 CHALLENGES

One of the greatest challenges for ORNL to achieve prominence in sustainable landscape approaches is overcoming traditional mindsets that are outdated. Creative and exciting things are happening nationally in the 'green' movement, and both public and private entities can either lead, follow, or be left behind. Sometimes public agencies are positioned to achieve what the private sector cannot, and often it is a combination of both public and private partnerships that offers the greatest synergy. ORNL is in a unique situation to lead by example in terms of sustainable landscape initiatives. Implementing sustainable landscape practices may take considerable patience, but progress can eventually be indelible and long-lasting.

5.2 CONSTRAINTS

Several key constraints need to be recognized in order to respond and make further progress in sustainable landscape initiatives, both aesthetically and environmentally. Some examples include:

- Contaminated Sites
- Utility Infrastructure
- Transition Campus Development
- Bureaucracy

Improving processes for addressing contaminated sites and utilities, though somewhat daunting, could be a long-term goal. Landscape planning can play an integral role to achieve this goal, and some of these efforts are already underway. Transition development on the ORNL campus has been underway in recent years, and this process is expected to continue. This raises some questions about the future direction of for delineating the landscape fabric, it also presents many new opportunities.

One of the most significant issues to address in landscape planning and implementation is dealing with bureaucracy. All building and infrastructure improvements are subject to timelines, budgets, funding, permitting, and procurement. Landscape elements and projects are particularly suseptable to these issues because of how funding is allocated. Nothing is more demonstrative of this issue than the federal Fiscal Year that ends September 30 each year, which dictates how ORNL funds projects. In Tennessee, the least desirable time to plant is summer; yet, the funding cycle inevitably encourages this to happen by default. Summer planting is problematic for a number of reasons:

- Heat and drought are typically the prevailing conditions, requiring extra watering, which is often expensive and ineffective in overcoming the physiological stress that plants are under during the planting process.

- Trees are often not available during summer months since they should be dug or pre-dug in the dormant season for optimal transplanting. As a result, leftover materials of inferior quality or alternative species are likely to be substituted. Digging trees in the summer is a risky endeavor and is not encouraged.

- Most horticultural planting operations should take place in any season other than summer.

Summer season is a good time for most construction and earthwork (i.e. installing hardscapes, excavating/shaping rain gardens and constructed wetlands) but not planting.

5.3 OPPORTUNITIES

The opportunities that may be available over the next decade on the ORNL campus far outweigh the challenges and constraints. ORNL is primed to be a national and regional model in environmental cleanup and sustainable campus development and stewardship. Given their past history, no entity should be more highly motivated or visible in this endeavor than ORNL. A national dialog is encouraging sustainable approaches through the LEED certification program, which is geared toward architectural structures, and the complementary Sustainable Sites Initiative, which is geared toward exterior and environmental settings. These programs have increasingly drawn attention to public and private sector opportunities that focus on a sustainable land and water ethic that is becoming increasing important to many.

Consistent with this focus on sustainability is an opportunity to develop a new ORNL campus environment that emphasizes comfort and functionality, aesthetic quality, walkability, connectivity to surroundings, and is ecologically responsible. Increasingly, new products and approaches are being developed that respond to this potential. ORNL has an opportunity to be actively involved in leading efforts to integrate sustainability into the campus setting. Recycled and salvaged materials, green infrastructure, blue infrastructure, energy conservation, bioretention, bioremediation, bioengineering, and ecological restoration are some of the sustainable solutions that directly or indirectly involve landscape strategies. In promoting this new landscape ethic, a critique of traditional landscape elements such as turf, rock, water, and mulch may be helpful in gaining a better understanding of a paradigm shift in sustainable landscape issues.

5.4 THE ROLE OF TURF

The ORNL campus has traditionally incorporated generous areas of turf. This manicured carpet of green is an important unifying element in the landscape; it allows rainwater infiltration, conveys runoff via drainage swales, and withstands light to moderate foot traffic for special events. However, from a sustainability standpoint, turf has several drawbacks. Turf is high maintenance, requires fertilizing and watering, and has a low value in terms of wildlife habitat and biodiversity.

One of the strategies for a sustainable landscape is to reduce turf in favor of other softscape components involving native plant choices. These include beds and borders, pocket woodlands, rain gardens, pocket meadows, ecological edges, pocket barrens, stream buffers, ledge gardens, and pocket wetlands, which are discussed in other sections of this report. Turf does have a place in the landscape for a couple of reasons. First, turf provides a nice visual contrast to the rich, and sometimes course, textures of native plant areas. Secondly, inclusion of turf in the foreground and along edges of spaces provides a zone of comfort as opposed to plantings or conservation zones that may be visually more chaotic. The real key in the sustainability equation is to balance the psychological aspect of well groomed landscapes with a more sustainable approach. Turf can play an important role even though there is potential to greatly reduce its extent within the ORNL campus (Fig. 15).

Fig. 15. Although high maintenance, turf may be included in the landscaping to provide visual contrast to landscaped areas.

5.5 ROCK: ISSUES AND OPPORTUNITIES

The use of rock in the landscape has universal appeal. It is visually attractive and it has a number of potential uses. From aesthetic accent to building and landscape construction to drainage and slope stabilization, rock has been used in the landscape for centuries. In recent years we have seen an increased demand for Tennessee indigenous stone, especially in landscape projects ranging from residential and corporate to public markets. Rock harvesting has emerged as a major issue in Tennessee for a combination of legal and environmental reasons. In June, 2011, Tennessee Governor Bill Haslam signed the Tennessee Rock Harvesting Act, which is intended to clarify and regulate the practice in the state through a permitting process. The legislation is supported by many individuals and groups, but others say it does not go far enough. Nevertheless, it does show the magnitude of the issue of rock harvesting impacts to slopes, soils, water, and vegetation that results from removing rocks from woodlands and natural areas. Also, conflict over surface rights versus mineral rights in land ownership is part of the legal controversy.

In regard to utilizing rock in the landscape, there are several factors relevant to sustainability, including sources, types of rock, and quantities used. Weathered indigenous rocks are considered by many to be the ‘jewels’ of the Tennessee landscape. Whether they are rounded river stones from young or old alluvial deposits, loose mountain boulders, or Tennessee field stone, they have a visual quality that makes them desirable for landscape use, but their quantity is finite. Only in terms of geologic time can these resources be considered renewable. Though seemingly abundant, they are nevertheless being depleted from natural areas and relocated to developed areas. A mismatch in geology may occur when rocks from a mountainous area are brought into the valley landscape. These rocks may not be consistent with the ‘sense of place’ as defined by the prominent limestone rock outcrops and ledges of the surrounding Oak Ridge area. Obviously, more energy is expended importing rock from farther distances, as is the case of sources in the Cumberland or Blue Ridge mountains.

Imported mountain and river rock has been widely used on the ORNL campus, especially with updated campus redevelopment projects (Fig. 16). It is recommended that this practice be reevaluated and additional guidance developed for future projects. Following are guidelines suggested in leading an ethical response to the rock harvesting issue:

- Eliminate further use of rock as a ground cover. Instead, focus on the strategic placement of rock as visual accent or to solve difficult slope, drainage, or riparian landscape issues (Fig. 17). Use of vegetative cover and bioengineering fabrics can play an increasing role. Extensive areas of existing landscape rock could be gradually shifted to more strategic locations over time.

- Eliminate or minimize further procurement of harvested landscape rock from the Cumberland or Blue Ridge mountain physiographic provinces. If rock is to be used, it could be salvaged rock from various developments and construction sites in the Ridge and Valley physiographic province (Fig. 18). This material is generally overlooked, and is often blasted, crushed, discarded, or covered during the development process.

- Minimize uses of river rock and river gravels from sources that are typically obtained from off-site locations having intrinsic environmental values in riparian zones and aquifer recharge areas (Fig. 19).

- Utilize salvaged concrete that results from demolition of old sidewalks, slabs, and other materials. The concrete pieces and fragments can be integrated and adapted into drainage swales and rain gardens in selected areas. Also, products are now emerging commercially that are made up of recycled concrete roofing tiles, paving stones, and block for professional landscape use.

Fig. 16. The practice of imported mountain and river rock is being re–evaluated because of harvesting concerns.

Fig. 17. Strategic placement of rock can help resolve difficult slope issues.

Fig. 18. Future use of rock will give preference to salvaged rock.

Fig. 19. River rock and gravels harvested from off-site locations will be minimized.

These efforts alone will not resolve all the impacts of rock harvesting in Tennessee, but they can have a positive influence throughout the region. The paradigm shift of reducing rock harvesting is consistent with and reinforces the overall Sustainable Campus strategy for Oak Ridge National Lab.

5.6 WATER: ISSUES AND OPPORTUNITIES

Water in the landscape is visually compelling and ecologically significant (Fig. 20). Important strides have been made in recent years in the improvement and stewardship of water resources on the ORNL campus, especially East Campus Pond, First Creek, White Oak Creek, and their associated riparian edges and buffers. At least two existing developed water features are prominent on the ORNL campus; one adjacent to the cafeteria complex and the other greeting visitors as they enter from the west portal along Bethel Valley Road. The East Campus Pond has been transformed ecologically, with its interesting aquatic vegetation and its landmark status upon entering the ORNL campus from the east portal.

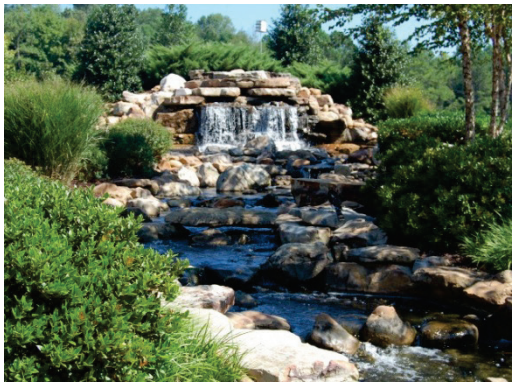


Fig. 20. Water in the landscape is visually compelling and ecologically significant.

The future landscape on the ORNL campus could continue to consider water as an integral component of the sustainable strategy. However, this strategy should not only focus on the flowing streams and water features. It could especially include intermittent drainage swales, rain gardens, detention basins, pocket wetlands (or bogs), and hardscape choices as a continuum. This, more than any strategy, has the potential to maintain and improve the quality of permanent streams. Paying attention to these areas can also help minimize the quantities and velocities of stormwater runoff that tend to erode and degrade the stream banks. A relatively new emerging term is 'blue infrastructure,' which encourages biological systems of water harvesting, cleansing, and reuse on-site. This approach is complementary to the concept of green infrastructure that ideally forms a seamless and transparent system of stormwater and graywater management, landscape irrigation, and daylighted streams and pocket wetands that could potentially replace some sections of underground pipes and culverts in the long term (Fig. 21).

Fig. 21. Drop ponds provide seamless and transparent system of stormwater management.

A related sustainability issue is the need to reveal in a transparent way the stream resources that are generally hidden by unmanaged vegetation. The STEM zone concept that is gradually being embraced on the ORNL campus has much greater potential as it seeks to balance and improve native riparian plant communities as both stream buffers and visual enhancement. These hidden resources could be opened up visually for the enjoyment of the visitors and workers. This alone can help create an amenity that does not require perpetual energy and upkeep as do the more developed water features with their associated pumping systems. One special opportunity exists at the concrete flume/spillway of the East Campus Pond. This area deserves an extreme makeover due to its highly visible location. Existing pumped water features could be supplemented with solar assisted energy as an added opportunity for demonstration. The stormwater detention basin just north of the roundabout and visitor center is also an opportunity to showcase and interpret the hydrology and habitat value of constructed wetlands as an integral part of the sustainable campus effort.

5.7 MULCH: SOURCES AND SUSTAINABILITY FACTOR

Mulch is especially useful in establishing planting beds, managing weeds, conserving moisture, and amending the soil as a long-term conditioner. While rock mulches are sometimes used and have certain advantages, organic mulch offers the most sustainable option for ORNL (Fig. 22). Currently, there is a wide range of mulches used on the ORNL campus. Often, local sources of shredded mulches are purchased, and some areas have extensive areas covered with pine straw. These are high quality and there are abundant sources; however, from a sustainability standpoint, it would be desirable to set up an on-site capability of chipping/shedding/composting. Various yard waste, leaves, trimmings, and brush from downed trees are not currently being recycled into the landscape. Discussions and studies are needed to determine the feasibility of including this capability. Even a modest operation would send a positive message to those who could learn that the best approach to managing yard waste is on-site, whether it is a back yard or a corporate or institutional campus. Possible cost savings might be a factor, but further study is needed to address this issue.

Fig. 22. Rock mulches are sometimes used and have certain advantages, organic mulch offers the most sustainable option for ORNL.

In terms of sustainability, pine straw is a questionable material to use since it is typically harvested from coastal longleaf pine ecosystems. It is a fine material if it is part of local yard waste; however, the energy issues and ecological issues surrounding it as an imported material are the main concerns. Similar issues relating to gravel and rock as imported groundcover/mulch materials are discussed in Section 5.5.

5.8 CONTAMINATED AREAS

There are a number of contaminated areas on the ORNL campus that are directly related to past and present activities associated with the mission of the facility. These include brownfields and greyfields where past structures have been removed over the years. Some of these former brownfield and greyfield sites have been cleaned up and reused, while others are vacant. Reclaiming these sites is a fairly straightforward process. The other type of contaminated sites are the rad zones, which have been exposed to radiation in sometime in the past. These sites have to be reclaimed before they can be reused for other uses.

5.8.1 Brownfields and Greyfields

ORNL is undergoing a number of changes as old buildings are torn down and replaced, and emphasis is on creating a cutting edge, sustainable campus. A primary principle of site renovation at ORNL is brownfield development, in which underused or abandoned facilities are redeveloped for productive reuse.

Brownfields are properties that may be impacted by hazardous substances, pollutants, or contaminants. Cleaning up such areas improves safety, protects the environment, creates a healthier environment, and reduces the impact of new development on existing natural resources.

Brownfield assessment and cleanup activities protect public health by removing and reducing contaminant exposures and public health threats. It is estimated that there are more than 450,000 brownfields in this country. ORNL's redevelopment of brownfield sites can be used as a model for the rest of the country.

Cleaning up brownfield sites can improve public health in a number of ways, including addressing safety or environmental concerns. It may also provide an opportunity for ORNL to create a safer, healthier campus through the redevelopment process. This redevelopment provides an opportunity to implement sustainable practices and create a greener campus.

Greyfields are properties in urban and older suburban communities that have been under-utilized or abandoned. On the ORNL campus, greyfields would be old, obsolete and abandoned sites.

5.8.2 Rad Zones

There are several locations on the ORNL campus where radioactive materials are present or radiation generating equipment is used (Fig. 23). Radiation levels in the air, water, and soil around these sites are closely monitored. These areas are roped off and clearly marked with yellow caution signs, and are generally not accessible. Unescorted access to Controlled Areas is limited to individuals who have received appropriate training and are wearing an assigned personnel dosimeter.

Fig. 23. There are several locations on the ORNL campus where radioactive materials are present or radiation generating equipment is used.

Radiological areas across the ORNL campus do not pose any risk to the visiting public as long as posting requirements and designated boundary restrictions are observed. They are, however, very unsightly and seem counter to ORNL's focus on a sustainable landscape (Fig. 24).

In keep with ORNLs focus on a sustainable campus, there are opportunities to restore some of the Rad Zones. ORNL is not the only place to be concerned about these types of sites. Over 1,000 United States locations, including both operational and abandoned sites, are contaminated with radiation. These sites range in size from small corners in laboratories to massive nuclear weapons facilities. The contamination may be found in the air, water, and soil, as well as equipment and buildings. These sites are closely monitored to prevent unnecessary exposure of the public. (http://epa.gov/radtown/clean-up.html)

Fig. 24. Rad areas are unsightly and seem counter to ORNL's focus on a sustainable landscape.

Because waste removal and storage is very expensive, the basic goal in the Rad Zones is "to remove as much of the radioactive waste as you can in as small a volume as possible."

Recommendations for Rad Zones include:

- Characterize site conditions
- Determine the nature of the waste
- Assess risk to human health and the environment
- Conduct treatability testing to evaluate the potential performance and cost of the treatment technologies that are being considered.

ORNL's existing 'Soils and Slab" program, which is managed by the Environmental Management (EM) program, focuses on restoration and rehabilitation of the Rad Zones. Each zone is evaluated and to determine the level of contamination for each, and sites are prioritized to determine which ones to do frst. This prioritization is based in part on plans for specifc sites. For example, if a building is planned for a given site in the very near future, EM may prioritize that site and address contamination issues. This typically involves removing the slab as well as a specifed depth of soil, which can range anywhere from 2' to 10' depending upon the level of contamination. If contaminated water is leaking into the groundwater, some type of waterproof barrier may also be needed.

Once EM has completed restoration of a specifc site, the site could be developed in a manner that is consistent with the Sustainable Landscape Initiative. This could be as simple as utilizing native grasses to add a patch of 'green' within the campus, or could include more ecologically diverse designs.

5.9 UTILITIES

Utilities fulfll important infrastructure needs at ORNL, and they present challenges for landscaping projects. Some of the areas dominated by utilities are being modified and updated with the ambitious redevelopment of the campus, and there will likely be continual aesthetic issues in the future as a result of above-ground utilities. Obviously, from a landscape perspective, it is desirable to consolidate, bury, and hide as many of the utilities as possible because they are visual distractions. When this approach is not feasible, utilities and utility zones must be recognized as landscape design problem that can be mitigated to some extent (Fig. 25). In some cases, it may be desirable to visually try to integrate utilities into the campus fabric making them as 'transparent' as possible. For example solar panels, interesting duct work, and utility vaults can all be handled this way. On the other hand, daylighting storm drains is ironically advocated as a way to improve the aesthetics and environmental values of the 'blue infrastructure'. Each utility consideration could involve landscape evaluation as an integral part of the planning and redevelopment process. Creative, collaborative solutions could make a significant difference by paying attention to the routing and presentation of each utility. For

example, landscape buffers and green screens may soften or screen many utilities while interpretive signage and artful presentation of specialized utilities may be effective in some cases (Fig. 26).

Fig. 25. Utilities and utility zones must be recognized as landscape design problem that can be mitigated to some extent.

Fig. 26. Landscape buffers and green screens may soften or screen many utilities.

While vegetative screens and buffers can play a major role in improving most utility zones, overhead electrical and fiber optic cables are an exception (Fig. 27). These types of utilities require diligent planning and management that recognize height restrictions, fall zones, clear zones, etc. Periodic review of vegetation within these zones is important to avoid critical outages associated with trees and limbs. Proper consideration of tree species selection in planting and selective thinning of natural succession is the most practical approaches. While these transition edges can be productive ecologically, they present the most challenge aesthetically.

Fig. 27. Poor vegetation management under utility lines.

6. GUIDING ENVIRONMENTAL DESIGN PRINCIPLES

The guiding Environmental Design Principles are intended to define the basic approach taken for each future site design project. These principles serve as a blueprint to ensure that future built projects on the Oak Ridge National Laboratory campus are consistent with environmental and sustainable goals.

6.1 SUSTAINABILITY

Sustainability is at the forefront of ORNL planning efforts. In 2002, ORNL began a major renovation that embraced the concept of a sustainable campus. ORNL's 68-year-old infrastructure was overhauled, and 15 new state-of-the-art buildings were constructed using a combination of federal, state, and private funds. These changes are part of ORNL's Sustainable Campus Initiative, which integrates energy and resource efficiency and cutting-edge technologies with operational and business processes.

The Sustainable Campus Initiative includes:

- **Energy use** – Implementing aggressive measures to conserve energy, while sustaining mission-critical high-performance computing and high-energy physics facilities.

- **Building efficiency** – Continually improving energy efficiency. Multiple LEED-certified new and upgraded existing buildings, including the first LEED-Existing Building certification. Improving building operation and maintenance.

- **Transportation** – Transforming ORNL's vehicle fleet with electric, flex- fuel, and alternative-fuel vehicles, plus 150 human-powered bicycles. Promoting greener commuting options.

- **Water conservation** – Reducing process and domestic water use to save millions of gallons of water

- **Landscaping** – Implementing natural landscaping and sustainable design principles. Using native vegetation and local materials.

- **Computers and information technology (IT)** – Reducing power consumption for high-performance supercomputers as well as desktop computers. Promoting the use of high-efficiency, networked duplex printers.

- **Purchasing, Property Sales** – Implementing procedures to purchase products that are more sustainable, require sustainable practices in contracts, and reuse assets. Donating unused assets to non-profit organizations or selling them to others

- **Pollution prevention and waste management** – Minimizing wastes at their source and through re-use and recycling. Reducing items sent to the landfill.

- **People** – Encouraging employees to incorporate sustainability in their work, home, and community lives. Promoting the exchange of information and ideas on everything from composting to choosing an efficient roof.

Sustainability is an important concept behind the ORNL Conceptual Landscape Master Plan. This document recommends that sustainability be considered in all decisions regarding the types of plants selected, how plant communities are designed and constructed, how maintenance is conducted, and how interpretive stories are told. The idea behind sustainability is to achieve a balance that is applicable to everyone. The most commonly used "official" definition comes from the 1987 United Nations' landmark report, Our Common Future, where sustainability was defined as "meeting the needs of present generations, while not compromising the ability of future generations to meet their own needs."

Sustainable projects for ORNL could be attractive and enjoyable for humans, promote biological diversity, contribute to the quality of the air and water, and reduce impacts of construction and human use. Any projects for ORNL should emphasize the use of green, sustainable materials, practices, and processes.

This means incorporating the following strategies:

- Integration of green infrastructure
- Utilization of renewable energy technologies
- Significant preservation/enhancement of ecology/habitat
- Incorporation of bicycle and pedestrian infrastructure
- Incorporation of cutting edge water management and recycling techniques
- Landscape design and management with limited or no potable water for irrigation
- Involvement of the campus community in the development of the plan/design
- Significant use of local materials
- Significant use of recycled materials
- Adoption of management plan/strategy to guide sustainable practice on-site during construction
- Significant use of native plants

Other sustainable practices include the following:

- Sustainable Ecology / Soils / Vegetation / Habitat Practices
- Limit development to the smallest possible footprint
- Protect significant habitat on the ORNL campus
- Preserve topsoil and limit compaction during construction
- Preserve and protect healthy soils, retaining topsoil, minimizing grading, compaction and soil disturbance
- Avoid disturbing and removing existing vegetation
- Remove invasive species.

- Maximize biodiversity and plan for connected habitats and native plant communities
-
- Sustainable Socio-cultural / Financial Practices
- Promote sustainability principles through incorporating education, demonstration areas, and programming on the ORNL campus
- Investigate and set up financing mechanisms to implement sustainability objectives
- Sustainable Water Practices
- Minimize excessive erosion and uncontrolled runoff.
- Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats stormwater runoff
- Utilize Best Management Practices such as biotention, swales, rain gardens, and constructed wetlands
- Specify water reuse strategies (rain water / grey water) within buildings.
- Reduce or eliminate potable water use for landscaping through use of captured rainwater, recycled stormwater, or treated water
- Implement water-conserving landscape practices, including soil improvement, use of mulch, limited turf areas, planting in relation to microclimate, waste scheduling and selection of plants with limited water needs
- Ensure water on site meets other hydrologic and environmental needs that the site may have
- Sustainable Materials & Waste Reduction Practices
- Ensure that the development reflects simplicity in form and function.
- Recycle and or salvage non-hazardous construction and demolition debris
- Consider the full life-cycle implications of materials
- Source local or regional materials
- Use salvaged, refurbished or reused materials and from rapidly renewable resources
- Consider utilizing on-site leaves, trimmings, and other organic landscape debris as a composted mulch material for reuse on campus

(a)

(b)

Fig. 28. An example of a parking lot (a) transformed into a garden (b).

6.2 SITE SELECTION

The basic idea behind this document is to help ORNL develop into a green, sustainable campus that integrates cultural, natural, and visual resources.

In order to create a green, sustainable campus, identifying strategic areas for landscape prototype demonstration projects is a priority. Some of these will occur in new development, while some existing landscapes may be retrofitted (Fig. 28).

Over time, these demonstration projects should be evaluated for both environmental and economic value. Concepts and strategies may eventually be measured as failures or successes, but both outcomes are equally important in the investigative process towards sustainability. The knowledge gained can then be synthesized and applied to various landscape situations campus-wide.

Site selection is guided in two general ways: 1) an area has been/is being/will be developed in such a way that calls for the application of an environmental design concept, or 2) an innovative environmental design concept has been developed and requires an appropriate site on which to be implemented.

When selecting a site to implement a specific type of concept, the following should be considered:

- Planned long-term use of the site
- Size and shape of the site
- Physical layout of the site – topography, soils, vegetation, etc.
- Site preparation costs
- Location of current or future utility lines
- Environmental issues such as wetlands, trees, jurisdictional streams
- Proximity of power lines, roads, or high-security areas

For example, the ORNL Landscape Committee may want to develop a rain garden on campus as part of a demonstration project. The site selection process in this situation involves identifying potential locations for a rain garden, then determining which of these is the most appropriate in accordance with the considerations listed above.

6.3 SITE DESIGN – WATER

It is important that all water on the ORNL campus be managed in a sustainable manner in order to maintain water quality and protect landscapes associated with water.

It is recommended that water management on campus include protecting and enhancing existing streams, addressing groundwater concerns, managing rainfall, and managing stormwater runoff. Many of the riparian areas on the ORNL campus have been impacted by development over the years, so emphasis in these areas is on restoration rather than preservation. Where areas are in a more natural condition, efforts should be taken to protect existing resources associated with those areas.

Rainwater harvesting refers to the capture and storage of rainwater, with the water typically being used for landscape irrigation as well as potable and non- potable indoor uses. Rainwater harvesting provides an opportunity to conserve and extend existing water resources. Locations and opportunities could be explored that may enable a series of ponds and cisterns to provide harvesting of rainwater and stormwater, especially for the

temporary establishment of ongoing landscape planting projects and priority turf areas. This adds a new layer of utilities infrastructure separate from potable water lines, but it may offer long-term advantages in cost savings and favorably demonstrate sustainable resource management.

There are a number of benefits to using water from rainwater harvesting systems. Rainwater harvesting makes economic sense, because the costs of collecting and treating rainwater are minimal, and utility bills can be reduced. Another big advantage is that less water flows into storm sewers, so less piping and infrastructure is needed to handle water. Rainwater harvesting also reduces potential flooding problems. One problem with rainfall harvesting is that at times there is not sufficient rain to depend on, especially during drought conditions.

During a high - intensity storm, often the soil is not able to absorb all of the water, and stormwater systems frequently overflow because of the volume of water. Slowing runoff helps reduce the erosion of stream banks. There are a number of BMPs for reducing stormwater runoff. Wet and dry swales are constructed to handle stormwater runoff on the surface, unlike stormwater pipes, which are underground. A grass or vegetated swale slows down water and also helps reduce pollution carried by stormwater. Surface swales are often used in concert with curbless streets to allow stormwater from paved areas to run into the swales.

Sediment controls capture sediment that can be transported in runoff. Filtration and gravitational settling during detention are the main processes used to remove sediment from urban runoff.

Sediment basins are constructed impoundment structures used to slow down stormwater runoff and allow sediment to settle out of the water. A sediment barrier is a temporary structure constructed of silt fences made of geotextile fabrics, straw or hay bales, brush, logs and poles, and gravel or other filtering materials. They are installed to prevent sediment from leaving the site or from entering natural drainageways or storm drainage systems. Sediment traps are small impoundments that allow sediment to settle out of runoff water.

Agencies such as TVA, NRCS, and EPA have been advocates for stream buffers for many years. Now local and state governments are implementing ordinances intended to reinforce the benefits of riparian or stream buffers for water quality improvement in urban watersheds. Secondary benefits associated with this emphasis on “green infrastructure’ is wildlife habitat improvement, conservation of native plant communities, and environmental education. With scientific consensus strongly favoring the concept of riparian buffers, the biggest challenge seems to be the lack of good examples that have aesthetic acceptance along with environmental improvement. Typical problems associated with unmown buffer areas are their tendencies toward appearing ‘messy’ or simply becoming visually dense thickets that invite invasive exotic plant populations. Overcoming these stereotypes will be crucial in gaining public acceptance of stream buffers in urban settings such as parks, campuses, residential suburbs, and commercial areas.

Water management also relates to irrigation practices. The best way to manage irrigation water efficiently is to avoid using irrigation whenever possible. The use of native grasses and native plant materials will reduce the need for irrigation. Irrigation is typically needed for initial installations, even if it is not needed for long-term health of the plants.

When landscape irrigation is needed, efforts could be made to reduce use of potable water. Water used could be restricted to captured rainwater, recycled wastewater, recycled graywater, air-conditioner condensate, blowdown water from boilers and cooling towers, or water treated and

conveyed by a public agency specifically for non-potable uses. Flow meters could be installed to record and monitor water use in the landscape irrigation areas. Alternative irrigation methods and water conservation strategies are also encouraged (see Fig. 29).

Fig. 29. Examples of creative stormwater catchment and conveyance.

6.4 SITE DESIGN – SOILS

Soils are one of the most important factors that can influence plant survival on the site. A few of the major characteristics of soil and examples of how they can affect plant health and survival are listed below.

- Texture – affects moisture levels and nutrient exchange
- pH – affects the ability of plants to take up nutrients and is a significant factor in determining appropriate plant palette selection
- Organic matter – affects nutrient and moisture availability
- Compaction – makes it difficult for plant roots to penetrate the soil; affects nutrient cycles & beneficial organisms
- Residual herbicides or pesticides – can affect plants and associated insects (Dorner, 2002)

Some microclimate factors to consider:

- Aspect of site
- Topography
- Shade
- Water availability
- Impact of built areas
- Amount of impervious surface nearby
- Hydrology
- Existing ecological communities
- Disturbances

6.5 SITE DESIGN – VEGETATION

All plant materials should be selected to provide a valuable landscape amenity that is both attractive and meets sustainability goals. Canopy trees, understory trees, shrubs, groundcovers, perennials, and other plant material should be utilized to add visual interest, help create a healthier environment, and complement existing vegetation.

Develop native plant palettes that will not only aid in interpretation of environmental design concepts for specific landscapes, but will also adapt to site conditions (soil, water, aspect, etc.) with minimal amendment. Although the demand for native plant material is gradually increasing in the nursery trade, many desirable species are still difficult if not impossible to find (especially in large sizes and quantities). It is important to design planting plans with this in mind to avoid undesirable substitutions during implementation. However, how can supply grow without rising demand? Some species may be contract grown in large quantities if adequate lead time is provided. This could encourage positive, viable relationships with local nurseries, as well as spur in-house collection/propagation programs. Sources of native plant materials should always favor locale first, then

region, a consideration known as provenance. Unfortunately, procurement is a challenge that will hopefully improve with designer awareness of provenance and more nurseries and plant brokers recognizing the trend toward natives.

Another consideration in specifying plant material is species versus cultivar.

A cultivar is basically a clone selected for certain desirable or consistent characteristics such as form or color. Within a campus setting like ORNL, there are valid reasons for choosing cultivars for certain areas within close proximity to buildings, walks, courtyards, plazas, streetscapes, etc., based on aesthetic unity or accent. However, biodiversity is increased by generally avoiding cultivars. For stream buffers, pocket woodlands, ecological edges, etc., relating to fringe natural areas and ecological restoration, non-cultivars should generally be the preference.

6.6 SITE DESIGN – MATERIALS SELECTION

Sustainable materials could be used for construction of site features and landscapes within the ORNL campus. These materials could be recycled materials, recyclable materials, or certified 'green' products. Paving could be selected to enhance the sense of a quality environment, be consistent with the architectural design guidelines, and promote sustainability goals. Paving materials should be appropriate for their use and installed properly to ensure their durability. When selecting materials, it is recommended that durability, ease of maintenance, and life cycle costs be considered. Sustainably produced materials with high recycled content or those made from plant-based products could also be considered since it promotes environmental sustainability.

6.7 SITE DESIGN – HUMAN HEALTH AND WELL-BEING

ORNL can promote human health and well-being by encouraging the development of environments that offer rich social, economic, and environmental benefits. Creating a green campus will help improve the welfare and well-being of the work force by incorporating physical activity into components of daily life; preserving and enhancing valuable natural resources; and creating a unique sense of community and place (Fig. 30).

Fig. 30. Examples of a green roof.

Sustainable design provides people the many benefits of encounters with nature and outdoor exercise. Research shows that a green view from a window or a lunchtime walk through landscaped grounds can reduce anxiety and aggression and restore concentration. For ORNL workers involved with demanding, cutting edge research, this type of mental break is invaluable.

Creating more outside recreational opportunities is beneficial because exercise can help reduce medical costs due to heart disease, strokes, osteoarthritis, diabetes, and some types of cancer.

6.8 CONSTRUCTION AND LANDSCAPE INSTALLATION

Sustainable construction practices involve the materials used for construction, the process of construction, and timing for when the construction is completed. Efforts could be taken to conduct a "carbon neutral" construction approach that takes into account all aspects of the construction process. For example, the cost and energy it takes to manufacture materials should be taken into consideration, as should any transportation or replacement costs associated with a specific material.

One problem in the past is that many landscape installments have been conducted during hot, summer months, and as a result there is a significant impact on the health of plant material. Many plants die and have to be replaced, or undergo severe stress that can lead to problems in the future. This issue is a major constraint previously discussed in Section 5.2; and it deserves special attention.

Fig. 31. An example of a gravel parking lot regraded to form vernal pools with lush vegetation.

6.9 OPERATIONS AND MAINTENANCE

The long-term and short-term operations and maintenance of the landscapes on the ORNL campus are critical for meeting stated sustainable objectives (Fig. 31).

The existing ORNL Landscape Committee provides the structure needed to ensure the overall success of the ORNL Sustainable Landscapes Initiative 2020 plan. Using a multidisciplinary team of professionals experienced in sustainable practices to collaborate on the design, installation, and maintenance of the ORNL campus landscape is critical.

A related issue is the need for improved facilities for the campus horticultural operations group. This is discussed further in Section 11.1 'Landscape Support Facilities'.

6.10 MONITORING AND INNOVATION

Monitoring helps determined how well the landscape master plan is meeting its stated goals and objective as well as identify potential areas of concerns.

Too often, monitoring is often overlooked, forgotten, or eliminated when budgets are tight.

Landscape monitoring can start with a cursory visual inspection of installed plants, but more detail is needed to ensure that new and establishment landscaping projects are meeting expectations.

In particular, monitoring should address:

- Overall condition of landscape installation
- Overall condition of individual plants
- Loss of plants from drought / inadequate watering
- Invasion of noxious weeds or invasive plants
- Impact from pedestrian traffic
- Impact of other human activities
- Browsing / grazing by wildlife

6.11 ORGANIZATIONAL UNITY: 'CAMPUS LANDSCAPE ARCHITECT'

While the ORNL Landscape Committee has been effective as an advisory group, this committee may need to consider additional personnel to meet the ambitious goals set forth for the next decade. A key addition to consider is a designated 'Campus Landscape Architect'. Whether in-house or a consultant, this professional addition could lend valuable unity that seems to have gaps currently. The role of the Campus Landscape Architect would be to work closely with the ORNL Landscape Committee while helping to orchestrate a harmonious composition of work that is seamless and unified day to day and year after year. This could vary from working closely with the ORNL horticultural operations group in training and field review for sustainable landscape installation and maintenance practices; designing certain project initiatives; working closely with other landscape architectural consultants and landscape contractors to provide orientation, expectations, and consistency as various projects are carried out; and serving as liaison between the ORNL Landscape Committee and other campus planning, engineering, and architectural initiatives.

7. APPLICATION OF ENVIRONMENTAL DESIGN PRINCIPLES

This section focuses on how the environmental design principles outlined in Section 6.0 can be applied to the ORNL campus. Implementation of the recommendations in this plan will take years, so it is important to identify a starting point and long term goals.

7.1 APPLYING PRINCIPLES AT A CAMPUS-WIDE LEVEL

The environmental design principles can be applied at a campus-wide scale that will help establish a framework for future projects. These campus-wide concept approaches focus on the main ORNL campus, but could be given to projects that reflect the basic principles of the Sustainable Landscapes Initiative. They are:

- Develop a green approach to campus growth
- Define a no-growth zone to protect existing green resources
- Emphasize a compact campus core
- Promote the concept of walkability
- Emphasize brownfield redevelopment in lieu of greenfield development
- Integrate ORNL research into the landscape

Develop a green approach to campus growth. As the campus continues to change and grow, it is important to manage growth in such a way that it protects valuable natural resources while allowing for the continued expansion of research efforts. Currently, the campus landscape is often overlooked, or considered secondary when decisions are made about the construction of new buildings, roads, or other physical elements.

Define a no-growth zone to protect existing green resources. One of the most striking visual aspects of the campus are the rolling hills, scattered woodlands, and open meadows that define the rural character of the landscape. In order to maintain this visual character, it is important to define a no-growth zone that will minimize development sprawl. The best way to protect the natural resources and open spaces is to prevent development from occurring there at all.

Emphasize a compact campus core. Keeping future development in the existing campus core will minimize impacts to existing natural resources, reduce the need for expanding the transportation and utility infrastructure outside the core area, and will reduce the resources needed for future growth. A compact campus also supports other major principles that focus on walkability and brownfield redevelopment.

Promote the concept of walkability. One of the key concepts for the ORNL campus is to get people to park their cars and explore the campus by foot or via alternative transportation such as electric shuttles.

Emphasize brownfield redevelopment in lieu of greenfield development. The basic idea behind brownfield redevelopment is to clean up sites that have already been impacted and construct new facilities on these sites instead of on undisturbed parts of campus. In order to maintain the

existing rural character of the campus landscape, it is recommended that the development of 'greenfields' (the natural, undisturbed parts of campus) be stopped.

Fig. 32. Existing conditions: roundabout.

Fig. 33. Existing conditions: limited riparian zone at 5000 area west of roundabout

Integrate ORNL research into the landscape. ORNL has the most elite scientific community in the country, and the research conducted on the campus could be incorporated into the landscape. Often, individual scientists and engineers may not consider their surroundings in terms of how it could be part of their research. There are two ways that the Sustainable Landscape Initiative can integrate with research: (1) specific landscape types can be developed that directly relate to research efforts that are occurring on campus; and (2) the landscape can influence future research, and researchers, by providing examples of the integration of people and environment.

7.2 CRITERIA FOR ESTABLISHING GOALS AND PRIORITY PROJECTS

It is suggested that four basic criteria be considered when evaluating how to prioritize goals and projects: visibility; environmental sensitivity; potential benefits; and funding requirements.

Visibility – Projects that are the most visible from major roads, viewing points, and public gathering spaces could be given a priority because they will have the most immediate impact upon the overall quality of the ORNL campus. Landscape projects near the entrances to the reservation establish a first impression for visitors and set the tone for the visual and environmental quality to be expected on campus. Landscape projects near the conference center are highly visible and would be seen by more people than projects on other parts of campus (Fig. 32).

Environmental Sensitivity – Emphasis could be given to environmentally sensitive areas that need to be protected or restored. For example, some riparian areas have already been restored via a variety of projects, and the impacts they have had on the campus are important. Riparian restoration projects improve water quality, reduce problems associated with stormwater runoff, improve visual quality, add much-needed wildlife habitat, and improve the overall environmental health of the campus. Since it is much easier to protect valuable natural and cultural resources than it is to repair them, it is recommended that every effort to preserve these areas is made (Fig. 33).

Potential Benefits – Landscape projects that provide the most benefits to the campus could be defined as priorities. Projects that provide many different benefits – visual, cultural, natural – will greatly improve the overall appearance and environmental health of the campus (Fig. 34). Some projects also help meet existing requirements, such as:

- Erosion Control Requirements
- Regulatory Requirements
- Water Quality Improvement
- Riparian Habitat Improvement

Meeting stormwater runoff requirements while also improving water quality and meeting stream buffer criteria is an effective way to stretch a budget and achieve multiple benefits.

Fig. 34. Existing conditions: East Campus Pond spillway/flume.

There are benefits to the overall reputation of ORNL to select projects that are consistent with the broader goals of the lab and the Department of Energy. For example, projects that utilize cutting edge technology and that focus on solar or wind energy may be priorities because they coincide with research efforts of the lab. Landscape strategies for the rad zones can serve as a national or international model on how to restore these severely impacted areas.

Landscape projects that address long-term maintenance issues could be a priority. Projects that are easy to install, affordable, have low maintenance, and lead to long-lasting life-cycle savings are important.

Fig. 35. Existing conditions: existing parking area.

Funding Requirements – In many cases, there isn't enough funding to implement all the projects under consideration, so it is important to be creative in how projects are conceived and developed. Landscape projects can be associated with other major construction efforts, such as a new building, road improvements, and infrastructure expansion. Every time a new construction project is discussed, one of the first questions could be how to integrate sustainable landscape initiatives with the project.

There may also be opportunities to implement landscape projects through funding associated with current research efforts. There may also be partnership opportunities with groups that want to establish native plant communities, provide environmental education opportunities, improve habitat for wildlife, remove invasive plants, restore and highlight locally native plants, or other opportunities that could take advantage of the ORNL campus setting (Fig. 35).

7.3 RECOMMENDED GOALS

Develop a green approach to campus growth.

- Integrate Sustainable Landscapes Initiative into the ORNL Campus Master Plan
- Ensure the ORNL Landscape Committee is involved with all planning and construction efforts that occur on the campus
- Explore ways to integrate planning efforts of the main campus with the overall ORNL Reservation
- Retrofit parking areas with green islands, buffers, raingardens, bioswales, greenscreens, shade structures, and porous paving

Define a no-growth zone to protect existing green resources.

- Determine no-growth zones for the campus
- Develop design guidelines for these no-growth zones in terms of protection, restoration, and enhancement
- Coordinate the idea of a compact campus with the ORNL Campus Master Plan

Promote the concept of walkability.

- Reinforce the idea of a central pedestrian and bicycle friendly streetscape along Central Avenue
- Connect the east and west 'quadrangles'
- Evaluate and define the concept of a 'central park'
- Implement a perimeter greenway with a conceptual route and strategic nodes/connectors

Emphasize brownfield redevelopment in lieu of greenfield development.

- Determine available brownfield sites
- Prioritize available brownfield sites based up phasing plans in the ORNL Campus Master Plan

Integrate ORNL research into the landscape.

- Develop demonstration gardens to highlight the different types of landscape features
- Develop a 'history park' or 'history walk' that would tell stories and interpret the legacy of ORNL
- Implement energy efficient innovations into the landscape, such as: solar panel shade structures; LED lighting; rainwater cisterns and water collection systems; eco-luminance installations; motion sensors to control lighting and signage; and piezoelectric generators for energy generation
- Conduct restoration of one or more rad zones to set an example for how to deal with these types of highly sensitive sites
- Develop an ecological research center that focuses on the use of native plant materials

Studies that could be facilitated by this ecological research center include:

- Availability of native plant species in the horticultural trade
- Ecological significance of selected native plant species
- Use of native species in rad zones remediation
- Systematic studies of native plant species for use in developed environments
- Landscape types and native species for carbon sequestration, energy conservation, and other uses
- Propagation and production of native species known to be difficult to grow and transplant
- Creative use of native species, such as using native sedges for potential applications in prevegetated mats, other bioengineering products, and green roofs
- Greener alternatives to riprap for critical slopes, drainage channels, and stream banks
- Short-term and long-term costs and benefits of various landscape types, including turf
- Economic and ecological costs of invasive exotic plant species
- Possible partnerships with the University of Tennessee or green industry partners to engage in this activity with ORNL

7.4 RECOMMENDED PRIORITY DEMONSTRATION PROJECTS

A suggested list of priority demonstration projects is presented below (see Figs. 36-39). Further descriptive information relating to these projects is included in Section 8.3 and the locations are shown on the 'Conceptual Landscape Master Plan' that follows.

- East Campus Pond and berm enhancements and associated courtyard and hardscape amenities
- East Campus Pond spillway/flume transformation
- East Campus Quadrangle sustainable landscape retrofits
- First Street pedestrian/streetscape improvements adjacent to stream buffer and rain gardens
- White Oak Creek greenway expansion
- Extend First Creek greenway to pond/natural area north of Bethel Valley Road, including an overlook
- Advanced Microscopy Lab sustainable landscape retrofit with courtyard adjoining wetland enhancements
- Portals and roadside sustainable landscape improvements
- Detention basin/demonstration wetland at 5000 area north of existing roundabout
- Develop Fifth Street greenway featuring daylighted stormwater system
- Develop courtyard east of 4500 N building
- Plant an iconic Oak tree in existing roundabout (transplant existing Hornbeam trees elsewhere)
- Begin greening existing parking areas and riprap
- Central Avenue streetscape improvements

Fig. 36. Existing conditions: Central Avenue streetscape.

Fig. 37. Existing conditions: forecourt for Graphite Reactor.

Fig. 38. Existing conditions: detention basin in front of the Advanced Microscopy Laboratory.

Fig. 39. Existing conditions: First Creek stream buffer demonstration project.

8. CONCEPTUAL LANDSCAPE MASTER PLAN

A landscape master plan for hundreds of acres must be considered conceptually before its features can be designed and carried out over several years. Thus, the emphasis on a long-term plan is highly conceptual and carries philosophy, recommendations, and guidelines more than a template. The following sections discuss the various elements that comprise the functional, aesthetic, and environmental components. Often, the terms 'softscape' and 'hardscape' may be useful in this discussion, but it is a complementary balance and integration of these elements that is important. This 'yin and yang' balance is the basis for accommodating people and the workplace support facilities while interweaving a landscape infrastructure. This philosophy may be useful in understanding environmental sustainability, campus stewardship, and quality of workplace.

8.1 SPATIAL ORGANIZATION

The organization of ORNL's campus landscape environment currently consists of a variety of structures and outdoor spaces that lack an overall unifying framework. Developing a more defined and integrated vehicular and pedestrian circulation system that connects to public open spaces will help create a well-defined spatial organization and character. This spatial organization will guide the construction and renewal of buildings, transportation on the campus, pedestrian walkways and trails, and the uses of the spaces outside buildings. Sustainable practices and green design have a high priority in the ORNL campus plan (Fig. 40).

Fig. 40. Sustainable practices and green design have a high priority in the ORNL campus plan.

ORNL's modernization plan involves three primary steps: (1) consolidating at the main campus, (2) vacating older space, and (3) building new and refurbishing key facilities.

The spatial organization of the ORNL campus is determined in large part by an infrastructure made up of the following:

- Paved public spaces such as plazas and courtyards,
- Pedestrian linkages such as sidewalks and greenway trails
- Vehicle linkages that includes roadway zones and parking areas

Permeable and porous paving products are increasing in availability for pedestrian areas, paths, parking, and other hardscape areas while also providing a more environmentally friendly alternative. Permeable paving contains enough void space to allow water to infiltrate runoff into the underlying soil. Porous pavement helps recharge groundwater and removes up to 80% of pollutants such as sediment, trace metals, and organic matter. Permeable and porous pavements allow the infiltration of rainwater and the treatment of runoff from adjacent impervious areas.

The use of pervious concrete is among the EPA's recommended best management practices. Pervious concrete has been used since the 1980s, and it is being used in areas where stormwater runoff is a major issue. Pervious concrete is a mixture of cement, coarse - graded aggregate, and water, with little or no sand used in the mix. The lack of a fine aggregate allows water to percolate through the concrete and into the ground.

Pervious concrete also has other benefits, such as reducing heat in urban areas. It also is better around vegetation since it allows water to get to the roots of the plants. Pervious concrete also reduces the need for large detention ponds and stormwater infrastructure. Although the initial cost is higher, concrete pavement has a significantly lower life - cycle cost than asphalt. Porous asphalt also has very little fine aggregate and a void content of up to 20%. It is often called a popcorn mix because of the size of the size of the aggregate and the coarseness of the asphalt binder that holds it together. Other pervious materials include bricks and concrete pavers established over specially designed layers of base aggregates.

Fig. 41. Public spaces on the ORNL campus include major and minor plazas and courtyards.

8.1.1 Public Spaces

Public spaces on the ORNL campus include major and minor plazas, and courtyards (Fig. 41). Spaces near the visitor center and facilities where larger numbers of visitors gather need to be able to accommodate these larger crowds. Most of the public spaces on campus are intended primarily for ORNL workers, though, so they can have a smaller physical size. All public spaces should be easily accessible, include overhead shelter and seating, and provide opportunities for public gatherings (Fig. 42).

Fig. 42. Public spaces should be easily accessible.

Major Plazas

Major plazas are large outdoor areas adjacent to buildings, and they usually have a combination of softscape and hardscape elements. They are typically used for outdoor gathering and assembling, and as event spaces.

Sustainable Landscape Opportunities – There are several opportunities for enhancing sustainability as part of major plazas. These include:

- Environmental (porous) pavers
- Shade structures/plantings
- Native plant community demonstrations
- Drought-tolerant lawn (or lawn alternative) demonstrations

Design Recommendations – Suggested design considerations for major plazas include the following:

- Incorporate potential amenities into major plazas, including: shaded walkways between buildings; shaded seating; bike stations; visual screens; trash/recycling receptacles; clear orientation and way finding; and interpretive signs
- Use plantings that are visually complex and worthy of close scrutiny (2003 LMP)
- Use plants that provide a level of detail that can be appreciated by nearby users (i.e. fragrance, flowers, texture) (2003 LMP)
- Reinforce the overall design concept of space by the use of plantings (2003 LMP)
- Provide a balance of shaded and sunny seating areas created by plantings (2003 LMP)

Minor Plazas

Minor plazas are medium-sized outdoor areas adjacent to buildings. These are usually a combination of softscape and hardscape and are used for outdoor dining, small public gatherings, and even for small, informal events.

Sustainable Landscape Opportunities – There are several opportunities for enhancing sustainability as part of minor plazas. These include:

- Environmental (porous) pavers
- Shade structures/plantings
- Native plant community demonstrations

Design Recommendations – Suggested design considerations for minor plazas include the following:

- Incorporate potential amenities into minor plazas, including: shaded walkways between buildings; shaded seating; bike stations; visual screens; trash/recycling receptacles; clear orientation and way finding; and interpretive signs

Courtyards

Courtyards are organized outdoor spaces adjacent to or between buildings. (The 2003 plan refers to them as nodes.) They are frequently used for outdoor dining/gathering space for building users. They are primarily designed for use by individuals and small groups. These outdoor areas are intended to provide space for a brief pause or a short conversation near the workplace.

One example of a courtyard project on the ORNL campus is the High Temperature Materials Laboratory (HTML) building. The landscape plan for the HTML building includes foundation areas and entrance ways surrounding the building as well as riparian restoration along White Oak Creek. The object is to create an aesthetic and environmental amenity that functions as a visual landmark. In addition to landscape feature plantings, especially near entrances, shade was also included for outdoor spaces and for energy conservation. The riparian restoration zone is based

on a 'plant communities' model that emphasizes adapted native plantings and removal of invasive exotic species. Interpretive signs inform building workers and visitors about the environmental landscape project and its benefits.

ORNL has recognized the opportunity to include the HTML building as part of an ongoing effort to retrofit existing landscape areas to the 'Sustainable Campus' initiative. The building complex receives high visitation and is considered a high priority to upgrade the landscape both visually and environmentally. With conceptual design, planting plans, invasive plant removal, management guidelines, and interpretive signage, this project can serve as a good example of 'sustainable' or 'environmental landscape design.'

Sustainable Landscape Opportunities – There are several opportunities for enhancing sustainability as part of courtyards (Fig. 43). These include:

- Environmental (porous) pavers
- Shade structures/plantings
- Native plant community demonstrations

Design Recommendations – Suggested design considerations for courtyards include the following:

- Incorporate potential amenities into courtyards, including: shaded seating/tables; bike stations; visual screens; trash/recycling receptacles; and interpretive signs

Fig. 43. A courtyard developed beside the HTML building on ORNL Campus featuring environmental pavers and native plants.

(Design and illustrations, Environmental Landscape Design Associates).

- Use plants used that provide detail that can be appreciated by users (i.e. fragrance, flowers, texture) (2003 LMP)
- Use large or small deciduous trees that provide shade and human scale (2003 LMP)
- Ensure the landscape does not obscure views to and from the node for non-paved gathering areas (2003 LMP)

8.1.2 Pedestrian Linkages

Pedestrian connectivity is important on the ORNL campus (Fig. 44). Typically, people drive to the campus, park their car, and then walk to where they need to go on campus. Parking is encouraged along the perimeter of the campus core, with sidewalks, trails, and access roads providing the primary access to within this part of the campus.

Sidewalks

Sidewalks consist of a network of paths and crosswalks connecting buildings, outdoor spaces, and parking areas. Sidewalks are using primarily to connect the different areas on the ORNL campus, but they are also used by pedestrians out exercising. Sidewalks are important because of the emphasis on making the core part of the campus more pedestrian only.

Sustainable Landscape Opportunities – There are several opportunities for enhancing sustainability along sidewalks. These include:

- Environmental (porous) pavers
- Shade structures/plantings
- Native plant community demonstrations

Design Recommendations – Suggested design considerations along sidewalks include the following:

- Incorporate potential amenities into courtyards, including: shaded paths where possible; safe pedestrian zones; ADA accessibility; visual screens; trash/recycling receptacles; clear orientation and way finding; connection to exercise program routes; and interpretive signs

- Provide a six foot wide (4 ft. Minimum) landscape planting strip between the curb and the sidewalk where possible (2003 LMP)

- Provide clear lines of site for pedestrian users (2003 LMP)

- Provide wider sidewalks along major pedestrian corridors

Fig. 44. Pedestrian connectivity is important on the ORNL campus.

Greenway Trails

Greenways trails include the campus-wide trail system connecting sidewalks and natural areas. They are used both for connectivity and for exercise. Greenway trails are intended more for secondary uses that are more casual in nature than sidewalks (Fig. 45).

Fig. 45. An example of a greenway trail.

Sustainable Landscape Opportunities – There are several opportunities for enhancing sustainability along greenway trails. These include:

- Environmental (porous) pavers
- Shade structures/plantings
- Native plant community demonstrations
- Corridors linking habitat areas

Design Recommendations – Suggested design considerations along greenway trails include the following:

- Incorporate potential amenities into greenway trails, including: shaded paths where possible; safe pedestrian zones and road crossings; ADA accessibility; bike stations; visual screens; trash/recycling receptacles; water fountains; clear orientation and way finding; connection with exercise program routes; access to natural areas along perimeter of campus; and interpretive signs

8.1.3 Vehicular Linkages

The automobile has had a major impact on the physical layout of the ORNL campus. Most workers and visitors drive to the campus, and the two entry points provide the first impression of the campus. The vehicular linkages include the main entry roads and the secondary interior roads, and the parking areas that are accessible from both.

Roadway Zones

The 2003 plan classified roadways, or streetscapes, as being either rural or urban. The rural roadways are those that lead from the ORNL entrances to the more developed areas of the campus. These roadways typically have a 35 mph speed limit, are automobile oriented, and have few sidewalks or trails for pedestrians. Many of the roadways have paved shoulders, grass transition areas, and are visually defined by woodland areas on both sides of the road.

Urban roadways are those located in the central part of campus. They typically have a lower speed limit, include sidewalks and crosswalks, and are enclosed by buildings that visually define corridors.

The two primary vehicular entries are located on Bethel Valley Road: one is west of First Street and the other is east of the 7000 Area. Secondary entries are located at the intersections of the laboratory's main streets with Bethel Valley Road.

Sustainable Landscape Opportunities – There are several opportunities for enhancing sustainability along roadway zones. These include:

- Reduce air pollution
- Provide shade
- Reduce heat index

Design Recommendations – Suggested design considerations for roadway zones include the following:

- Incorporate potential amenities into roadway zones, including: safe driving conditions/pedestrian crosswalks/bike lanes; clear and effective wayfinding; and visual screens and enhancements
- Minimize, capture, and reuse stormwater runoff along urban roadways
- Utilize plants that require full sun to partial shade, moderate to limited amounts of water, and air pollution tolerance
- Utilize native plantings along rural roadways that are similar in species to the neighboring habitat (2003 LMP)
- Use planting arrangements that complement existing landscape and accentuates topography and rural roadway alignment (2003 LMP)
- Maintain views and vistas along rural roadways
- Use native grasses and trees as the primary plantings along rural roadways (2003 LMP)
- Provide clear lines of site for both pedestrians and vehicles along urban roadways (2003 LMP)
- Plant landscape buffer strip with a low maintenance evergreen groundcover along urban roadways (2003 LMP)

Parking Areas

Parking Lots are necessary to provide workers and visitors a place to park their car. Access from parking areas to major buildings and public gathering spaces is important (Fig. 46).

Sustainable Landscape Opportunities – There are several opportunities for enhancing sustainability along parkway areas. These include:

- Environmental (porous) pavers
- Runoff catchment/treatment (bioswales, raingardens, etc.)
- Planting islands
- Shade trees/structures
- Native plant community demonstrations
- Solar panels
- Interpretive signs

Design Recommendations – Suggeste design considerations for parking areas include the following:

- Incorporate potential amenities into greenway trails, including: adequate parking space for employees and visitors; convenient accessibility to buildings and trails; and shade

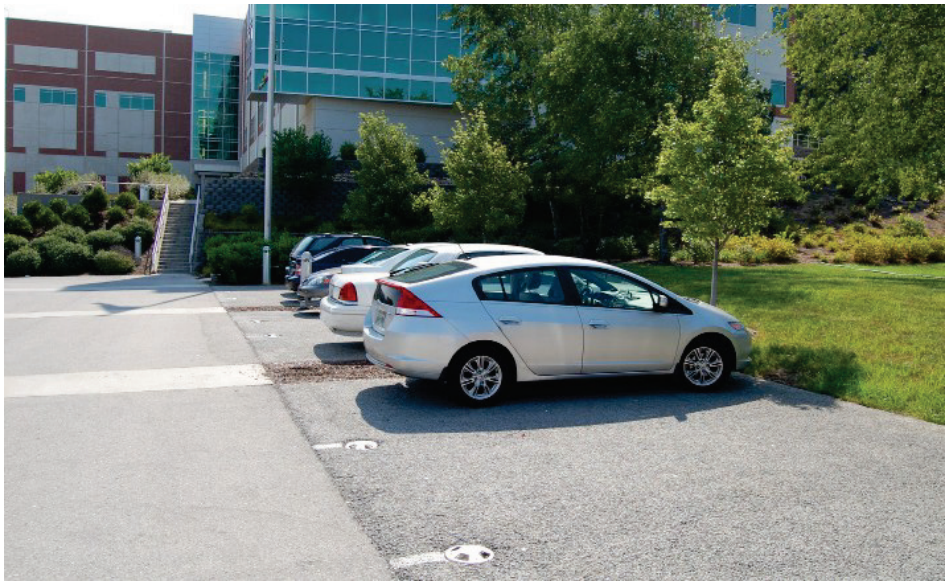


Fig. 46. Visitor Center parking includes use of permeable pavement.

- Provide planting islands throughout the lot so that shade trees can be used to shade a target amount of at least 30 percent of the lot (2003 LMP)
- Make parking islands the size of at least one parking space per tree (2003 LMP)
- Use low maintenance groundcover within parking islands under the shade trees (2003 LMP)
- Use shade trees that do not introduce excessive litter or sap that may damage or deface parked vehicles, nor attract roosting birds (2003 LMP)
- Soften the visual impact of parking areas with naturalistic plantings and berms (2003 LMP)

8.2 CAMPUS GROUNDS

The ‘campus grounds’ are essentially the green spaces that interconnect the buildings, parking areas, outdoor sitting areas, walks, roads, and streets. This is a generic term intending to serve as a reference to discuss sustainability issues and challenges relating to the traditional landscape spaces within the ORNL work and visitor environment. In the context of this report, we are referring to the ‘softscape’.

8.2.1 The 'Softscape' Amenity

Fig. 47. Softscape amenity..

Softscape is a loose but useful term that describes those landscape elements that relate to plantings, lawn areas, drainage features, and conserved vegetation within the immediate campus vicinity. These amenities can help to soften and unify various architectural building styles, screen utility and parking necessities, and especially provide visual and environmental transition. This campus fabric may also be considered valuable 'green infrastructure' that can mitigate the often harsh effects of construction impacts in the 'built' environment such as stormwater runoff. The softscape can have a prevailing effect on the aesthetic quality and 'sense of place' as much as any other influence relating to the campus. In fact, the term 'campus' invokes a collection of academic, research, or office buildings with a generous amenity of grounds and open space as an aesthetic expectation (Fig. 47).

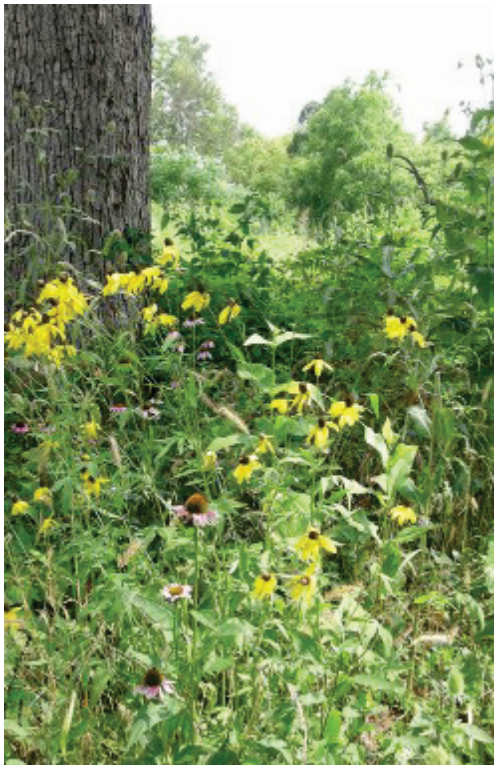


Fig. 48. Use of locally native plants in the landscaping provides many benefits.

8.2.2 Why Native Plants?

Regional and national trends toward the advocacy and use of native plants in the landscape have been significant over the past two decades. There are many good reasons, and ORNL has aggressively incorporated natives in the campus landscape in recent years (Fig. 48). This effort is not without challenges and issues, which also deserve attention.

Native plant communities are lost each year to 'sprawl', natural resource extraction, and the building of expanded transportation and utility infrastructures. Although the actions of state and federal agencies, conservancies, and land trusts have been effective in preserving many unique natural areas, the integration of native plant communities in the urban and suburban fabric has been very weak. This is additionally compounded by the spread of exotic 'pest plants' that have escaped cultivation unintentionally.

An executive order by President Bill Clinton in 1999 mandated that federal agencies seek to restore native species, and this followed a 1995 Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds that listed planting 'regionally native plants' as one of its five guiding principles (EPA, 1995).

In practical and ecological terms, some of the advantages are:

- Native plants can reflect and reinforce the surrounding setting , and connect with the regional 'sense of place'
- Native plants support indigenous insect, bird, and wildlife populations without ecological repercussions that many exotic plants may introduce
- Well selected for site conditions, they are culturally adapted; thus, potentially can thrive once established
- Even though some native species can be 'aggressive', they do not threaten ecological succession processes in the locale or region
- Native plants can offer unique richness and aesthetic interest in landscapes often overlooked by typical landscape development

Some of the challenges in incorporating native plants in landscape projects are:

- Landscape design with native plants is specialized and 'knowledge intensive', since the palette and cultural preferences are not as well known as most of the mainstream 'ornamental' plant materials

- Availability of nursery propagated materials, while increasing, is still a significant drawback in designing and implementing native plant landscapes

- Landscape contractors and grounds personnel are typically not acquainted with identification, weeding, maintenance, and 'grooming' practices associated with the aesthetic presentation and related ecological factors involving native plant projects

- Additional research is needed in the propagation, growth, and culture of many native species that are candidates for inclusion in landscape projects

- Regionally, the native evergreen shrub and ground cover species palette is quite limited, thus imparting a need to adjust mindset expectations visually toward accepting a different aesthetic look

8.2.3 Plantings as 'Plant Communities'

Despite the significant trend in utilizing individual native species in landscape projects for perceived sustainability benefits, attention to the various layers and selecting a palette of plants matching their ecological niche is the most effective way to achieve maximum success and benefit (Fig. 49). This requires a rationale based on an understanding of plant communities dynamics. Additionally, intimate knowledge of the site conditions is critical, especially in highly disturbed soils and landscapes often encountered throughout the ORNL campus. Therefore, observing adjacent natural areas and following nature's lead in predicting compatibility of plants and site ecology is helpful; but, also probing and sampling the project soils to determine depth, compaction, moisture, texture, and pH factors is also important.

Fig. 49. Plantings as ‘Plant Communities’.

Contrived landscape designs may attempt to replicate nature's patterns, but usually there are many extractions and simplifications for various reasons, including horticultural and maintenance factors. Nevertheless, plant community models and prototypes could be the primary inspiration for good landscape design and horticultural management within the ORNL campus setting.

8.3 PLAN OVERVIEW

The conceptual landscape master plan offers a graphic representation of the ideas included in this document (Fig. 50). It is not inclusive of many opportunities that may be site specific; however, it is intended to give a broad vision and direction over the coming decade. Some of the ideas reflect the draft ORNL Campus Master Plan, and some components are complementary recommendations unique to the Sustainable Landscapes Initiative.

Key features of the plan in agreement with the ORNL Campus

Master Plan include:

- Central Avenue streetscape transformed into a pedestrian and bicycle friendly connector between the East and West Campus areas.
- Partial day-lighting of culverted and piped stormwater to reveal a more transparent and ecologically improved hydrology
- Additional retention basins and ponds in strategic locations that may serve to impound water for improvement of quality, reduction of downstream flooding, or for reuse in landscape irrigation
- A future 'central park' stretching both north and south of Central Avenue adjoining amenities including a food services area for the west campus, a transit center, and a historical interpretation node surrounding and including the historic Graphite Reactor.
- Emphasis of laboratory and office growth in infill areas that are in need of environmental cleanup, restoration, and redevelopment.
- Emphasis on 'sustainability' in energy and carbon footprint reduction, water and environment, transportation, and ultimately a 'Net Zero Campus'.
- Suggestion of additional roundabouts at major intersections along Bethel Valley Road, especially at First Street and Fifth Street.

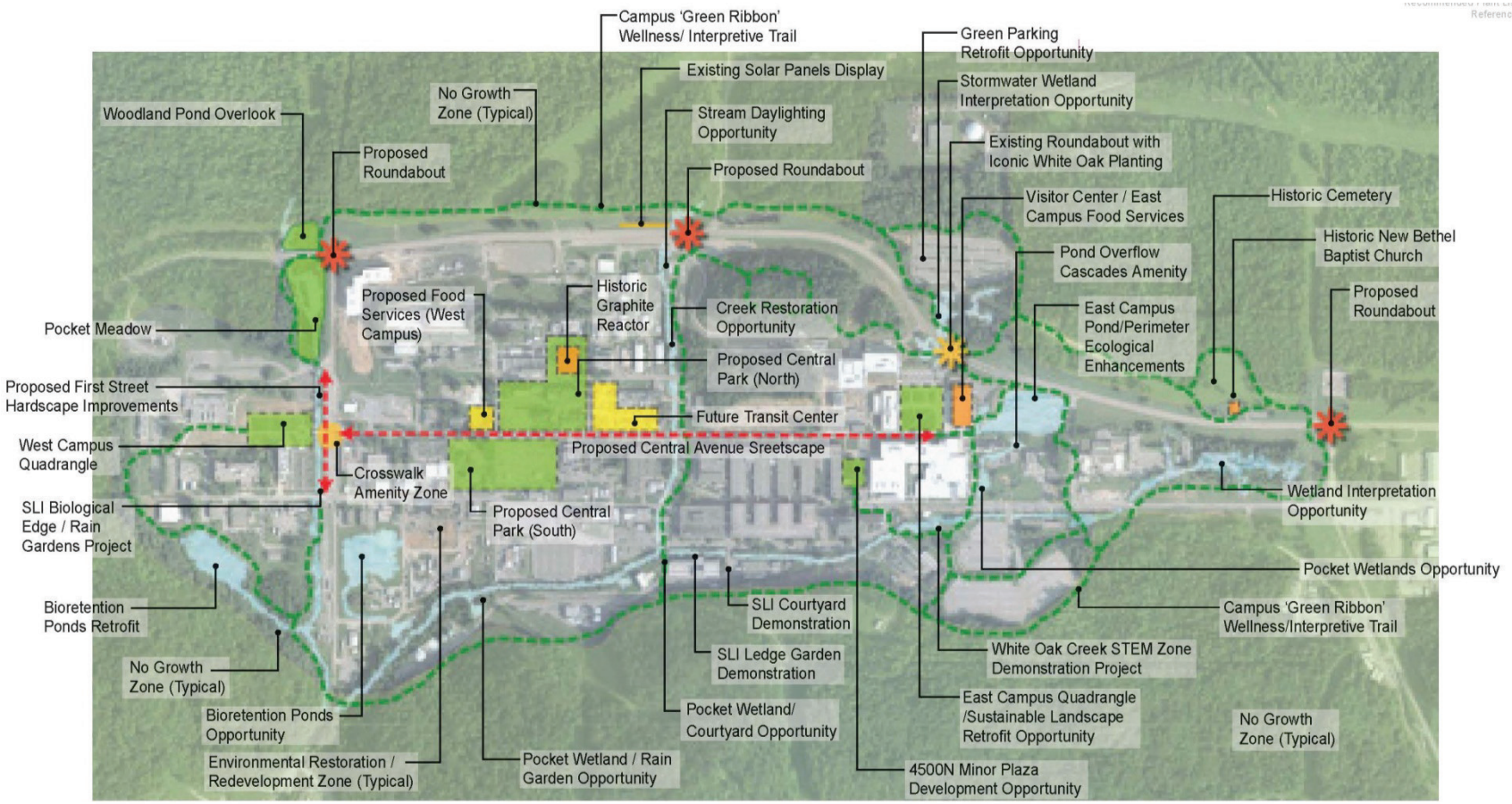


Fig. 50. Conceptual Landscape Master Plan.

Features of the plan that differ from the draft ORNL Campus

Master Plan include:

- Omission of the proposed roundabout at the west terminus of Central Avenue due to the potential disruption in the pedestrian/bicycle emphasis of the east-west streetscape connecting the East Campus Quad with the West Campus Quad.
- Delineation of 'no growth' limits that would discourage any further encroachment into existing woodland and hillside zones north of Bethel Valley Road and south of White Oak Creek.

Proposed new features in the Sustainable Landscapes Initiative would include:

- An integrated greenway/wellness/interpretive trail system ('Green Ribbon') that would eventually surround the campus and reach into the environmental, cultural, and green space nodes of the campus. This is not intended to represent a recreational diversion from work; but, the system could especially promote walking and bicycling within the campus and encourage informal and organized wellness programs before and after work or during the lunch break. Additionally, by following routes along streams, ponds, wetlands, meadows, and woodlands the interpretive story of the integrated 'sustainable campus landscape' would be concurrently showcased. The route for the 'Green Ribbon' is highly conceptual. It should be designed to achieve a sensitive fit to the topographic, vegetation, and drainage conditions as its development eventually interconnects and circumscribes the campus perimeter.
- Selective SLI demonstration sites such as courtyards, ledge gardens, and green screens promoting/featuring sustainable landscape applications within the central campus area
- Proposed streetscape improvements along First Street. These are intended to better reveal the west campus 'gateway' and present the stream buffer, rain gardens, and ecological edges as SLI demonstration projects. These streetscape improvements should include an attractive walk along the existing curb line on the west side, a specially designed crosswalk pavement feature at the intersection of First Street and Central Avenue, and the eventual elimination of parking on the west side of First Street.
- A 'cascades' water amenity feature to replace the existing concrete flume that serves as an overflow from the East Campus Pond.
- Various pocket wetlands and rain gardens throughout the campus and fringe areas to highlight and interpret the hydrology and 'blue infrastructure'. A highly visible priority area is potentially the sunken stormwater drainage depression west of the existing roundabout near the Visitor and Conference Center and north of the visitor parking lot.
- Aggressive STEM zone management to better reveal the attractive streams that flow through the campus.
- Ecological restoration of all riparian areas that may need attention
- Expanded development of pocket woodlands, meadows, and barrens within the fringe campus areas.
- Phased greening of selected 'rad zones', surface parking areas, and riprap dominated landscapes.

9. PROTOTYPE CONCEPTS FOR SUSTAINABLE LANDSCAPES

Within the framework of a sustainable campus vision, there are many opportunities to develop sustainable landscape elements that will collectively create a holistic composition. By creatively addressing site specific issues, each element can inherently contribute to embracing the broader ethic of the Sustainable Landscapes Initiative. The following environmental design concepts have the potential to translate this ethic into tangible environmental benefits and amenities for the ORNL campus community.

9.1 DESIGN CONCEPTS FOR MANAGING STORMWATER

Emerging in the national dialogue is 'blue infrastructure' that complements the more familiar term 'green infrastructure'. Some are now promoting the idea of 'blue-green infrastructure', which implies a seamless landscape fabric that comprehensively addresses greening of the built environment while managing water resources responsibly. This innovative concept can be incorporated throughout the ORNL campus by focusing on landscape projects such as riparian enhancements and restoration, retrofitting stormwater detention basins, creating pocket wetlands, bogs, raingardens, and bioswales.

9.1.1 Stream Buffers

Stream buffers are strips of riparian vegetation along waterways that physically separate and protect the water and associated wildlife from land development activities (Fig. 51). Roads, parking lots, buildings, and manicured landscapes have replaced natural buffers that once protected our waterways form erosion and pollution. Without these buffers, stormwater flows directly into our waterways carrying sediments and other harmful contaminants, while the unstable banks fall in and wash away.

Fig. 51. An existing stream buffer on ORNL Campus.

ENVIRONMENTAL BENEFITS:

There are several opportunities to demonstrate the Sustainable Landscapes Initiative throughout the ORNL campus by creating, enhancing, and managing stream buffers because they:

- Prevent erosion along waterways
- Slow stormwater to reduce drainage problems and flooding
- Improve water quality by filtering pollutants/sediment from runoff
- Decrease turf/increase biodiversity
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Provide shade that lowers water temperature for aquatic life
- Create habitat and nesting sites for wildlife
- Provide more diverse food supply for wildlife and insects

- Bring beauty, visual interest, and seasonal variation to the landscape
- Showcase native plant communities

AMENITIES:

- Interpretive signs
- Plant identification markers
- Overlooks and sitting areas
- Wildlife nesting boxes

RECOMMENDED PLANT PALETTE:

In the context of East Tennessee streams, there is typically a gradation of soil and topography conditions from dry (up) to wet (low). The 'Upland/Lowland' column of the plant list is a general guide for selecting species best suited to thrive in these diverse conditions. See 12.1.1 on page 87 for plant list.

EXAMPLES OF HOW TO CREATE A STREAM BUFFER IN A PUBLIC PARK SETTING

This is one example of how to create a stream buffer in a public park setting. Typically, park grounds are maintained as lawn and mown to the water's edge. Turf grass lacks roots deep enough to stabilize soil, which leads to erosion when overly manicured. If left unmaintained, a thicket of invasive exotic species would likely develop.

Here, a mow-line was painted on the ground, fallen leaves were raked into the no-mow zone to discourage weed growth, erosion fabric was pinned in place, and plugs of native sedge (Cherokee Sedge) were planted directly through the fabric in Fall. Some trees and groups of native shrubs, grasses, ferns, and wildflowers were also planted to frame views of the stream. With bi-annual grooming (requiring native plant knowledge and horticultural expertise) this stream buffer provides an attractive transition between the lawn and the stream while reducing erosion and increasing both the environmental and aesthetic value of the park.

Here is another example of a stream buffer demonstration project in a public park setting. Herbicide (approved for use near streams) was applied within the no-mow zone instead of the leaf mulch/erosion fabric combination. The sedge was then planted directly into the dead turf, as were trees, groups of shrubs, grasses, ferns, and wildflowers.

(Design and illustration, Environmental Landscape Design Associates)

Below is a watercolor illustration (which was incorporated into an interpretive sign) depicting the mature stream buffer.

(Design and illustration, Environmental Landscape Design Associates)

9.1.2 Pocket Wetlands, Bogs, and Detention/Retention Basins

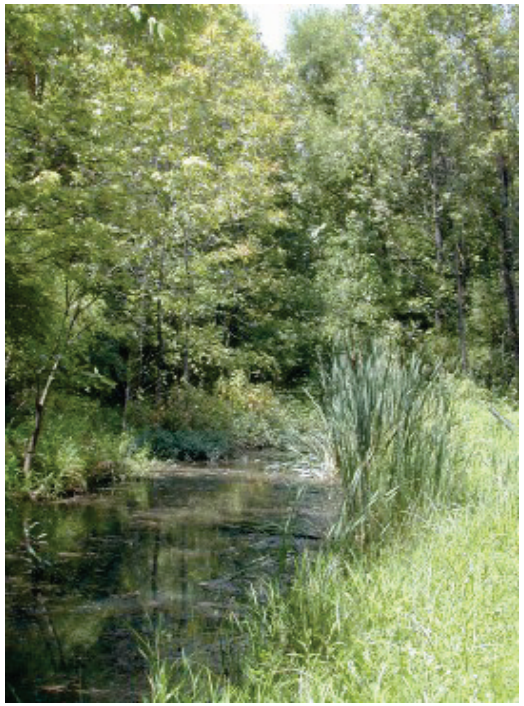


Fig. 52. A created pocket wetland.

Wetlands, bogs, and detention/retention basins can all improve water quality by forming an interconnected system that slows and filters stormwater runoff (Fig. 52). Wetlands and bogs are existing or created depressions where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on the surface. Among the different types of wetland designs are shallow wetlands, extended detention shallow wetlands, pond/ wetland systems, and pocket wetlands. Shallow wetlands consist primarily of marshes, and water treatment occurs in these shallow areas. Extended detention shallow wetlands are designed to hold stormwater and then release it over a period of time. With pond/wetland systems, the ponds trap sediments and reduce runoff going into the wetlands. Pocket wetlands are intended for smaller drainage areas and often are developed in areas with high groundwater as well as areas adjacent to natural open space.

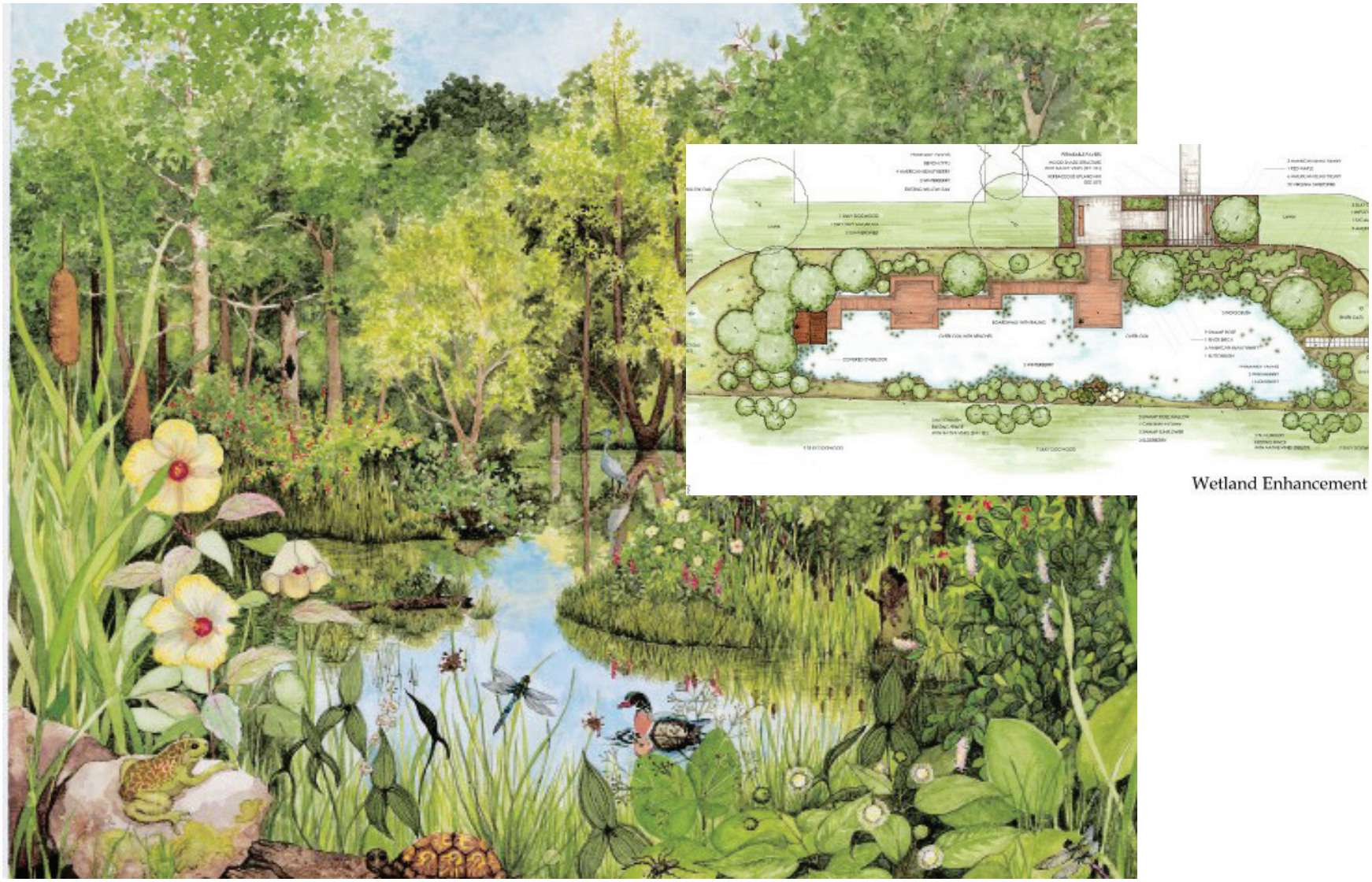
The concept of 'blue-green infrastructure' can be demonstrated by creating pocket wetlands or retrofitting existing detention basins to resemble natural wetlands or bogs. The ecological and aesthetic value of each of these landscape components can be maximized by enhancing or restoring associated native plant communities within the aquatic zone and fringe areas (Fig. 53).

Fig. 53. Cardinal Flower and Buttonbush.

ENVIRONMENTAL BENEFITS:

Creating, enhancing, and managing pocket wetlands, bogs, and detention/retention basins can enhance sustainability because they:

- Reduce flooding by slowing/catching/retaining stormwater runoff
- Improve water quality by filtering pollutants/sediment from runoff
- Help recharge local ground water supplies
- Decrease turf/increase biodiversity
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Create habitat and nesting sites for wildlife
- Provide more diverse food supply for wildlife and insects
- Bring beauty, visual interest, and seasonal variation to the landscape
- Showcase native plant communities



Above is a design for retrofitting an existing detention/ retention basin at an elementary school into a wetland. The plan features native plants, environmental pavers, outdoor classrooms, a boardwalk and overlooks, interpretive signs, and a vine covered wood fence (to replace existing chain link). The illustration at left depicts a pocket wetland featuring native plant and animal species.

AMENITIES:

- Interpretive signs
- Plant identification markers
- Overlooks and sitting areas
- Boardwalks
- Greenway node
- Wildlife nesting boxes
- Potential landscape irrigation source
- Water treatment demonstration

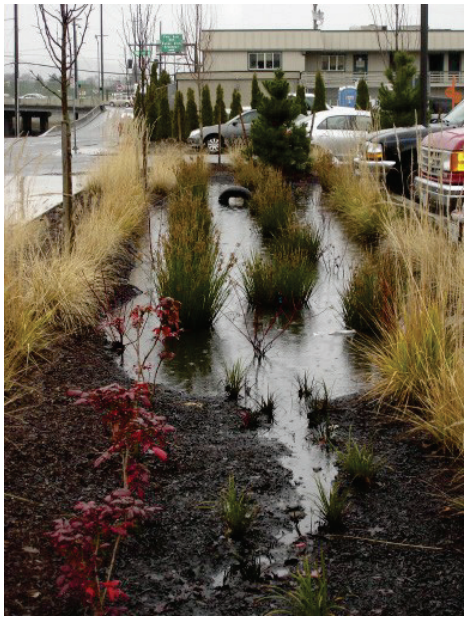


Fig. 54. Rain garden.

RECOMMENDED PLANT PALETTE:

See 12.1.2 on page 88 for plant list.

9.1.3 Raingardens and Bioswales

Fig. 55. Example Rain Garden design plan.

Rain gardens are small bioretention ponds or depressions that slow down stormwater and allow it to percolate into the soil (Fig. 54). The basic idea of a rain garden is to capture stormwater runoff from impervious areas like roofs, driveways, walkways, parking lots, and compacted lawn areas and divert it into vegetated areas instead of having it run off into the storm sewer system.

Bioswales are similar to raingardens in that they are contoured vegetated areas intended to slow and filter Stormwater (Fig. 55). Technically they differ in that they typically convey a positive flow of water during storm events without pooling or ponding in depressions. They may be connected with raingardens, bogs, or wetlands (Fig. 56).

ENVIRONMENTAL BENEFITS:

Incorporating raingardens and bioswales into areas impacted by development throughout the ORNL campus can enhance sustainability because they:

- Reduce flooding by slowing/catching/retaining stormwater runoff
- Improve water quality by filtering pollutants/sediment from runoff

- Help recharge local ground water supplies
-
- Decrease turf/increase biodiversity
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Create habitat and nesting sites for wildlife
- Provide more diverse food supply for wildlife and insects
- Bring beauty, visual interest, and seasonal variation to the landscape
- Showcase native plant communities

AMENITIES:

- Interpretive signs
- Plant identification markers
- Wildlife nesting boxes
- Water treatment demonstration

RECOMMENDED PLANT PALETTE:

See 12.1.3 on page 89 for plant list.

9.2 POCKET WOODLANDS AND WOODLAND ZONES

Pocket woodlands (Fig. 57) are densely planted 'islands' of canopy, understory, and small flowering trees mulched with a ground layer of leaf litter, or duff. They typically have a clearly defined outer edge and help create an 'instant' buffer or screen resembling a small woodland.

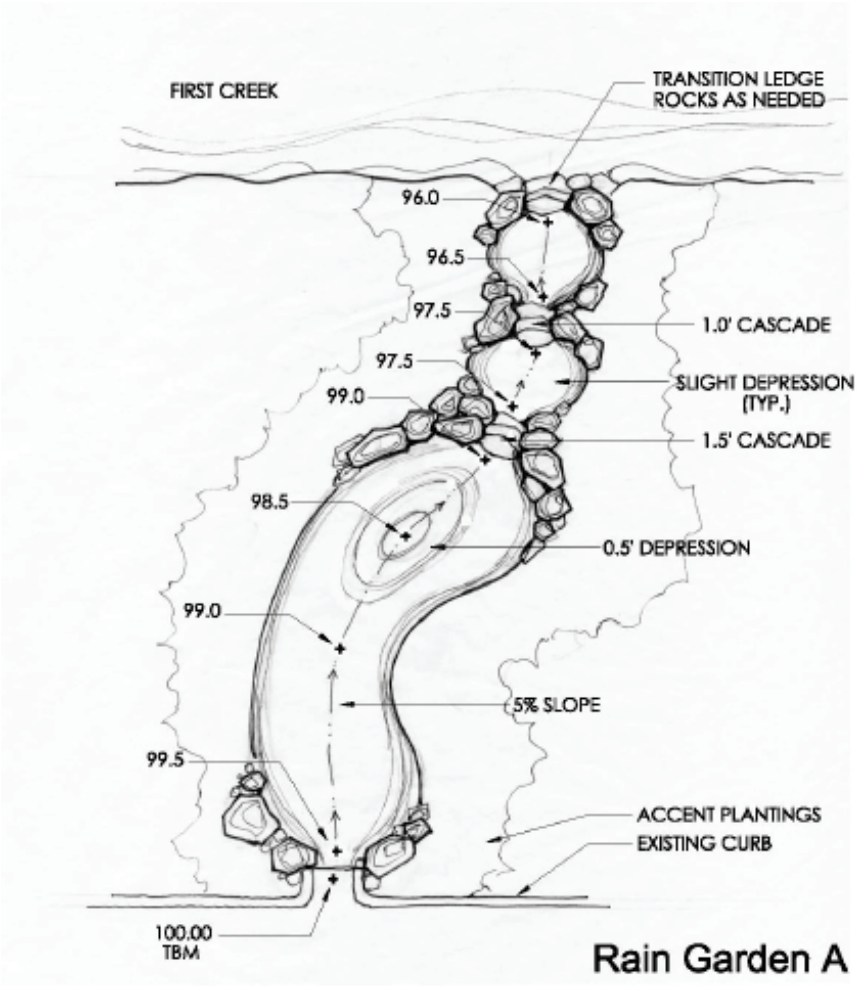


Fig. 56. Connected with raingardens, bogs, or wetlands.

Woodland zones of the Oak Ridge Reservation (Fig. 58) surround the campus and access roads. In some areas, it may be advantageous to expand woodlands into the fringe areas. These created woodland zones share the same plant palettes and implementation strategies as pocket woodlands.

Shown above is one of four curb-cuts along First Creek on the ORNL Campus. The illustration to the right depicts a raingarden intended to slow and filter stormwater runoff from the adjacent road and parking areas before it reaches the stream. The sketch on the previous page is a plan view of the raingarden, detailing the appropriate elevations, slope, depressions, and cascades.

(Design and illustration, Environmental Landscape Design Associates)

ENVIRONMENTAL BENEFITS:

Replacing turf by creating pocket woodlands and expanding woodland zones will:

- Decrease turf/increase biodiversity
- Improve water quality by slowing runoff and increasing infiltration more effectively than turf
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Minimize level of maintenance complication by eliminating the need to mow around individual trees
- Showcase leaf/yard waste/compost recycling demonstration
- Create habitat and nesting sites for wildlife
- Provide more diverse food supply for wildlife and insects
- Bring beauty, visual interest, and seasonal variation to the landscape
- Showcase native plant communities

AMENITIES:

- Interpretive signs
- Plant identification markers
- Wildlife nesting boxes
- Sitting areas

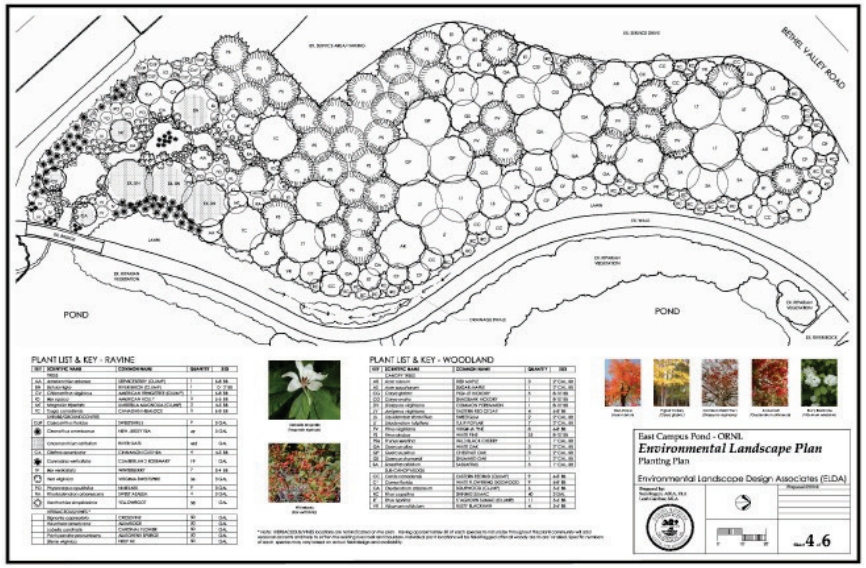
RECOMMENDED PLANT PALETTE:

See 12.2 on page 90 for plant list.

Fig. 57. An example of a pocket woodland.

Fig. 58. An existing woodland edge on the Oak Ridge Reservation.

Shown above is an existing planting bed adjacent to the East Campus Pond on ORNL Campus.



Above is a design for this same area to create a pocket woodland by enhancing the existing plantings with species found in an existing woodland across Bethel Valley Road.

(Design, Environmental Landscape Design Associates)

9.3 VEGETATIVE BUFFERS AND SCREENS

These are dense plantings in masses and drifts where adequate space is available. They help screen visual clutter, utilities, service areas and other unattractive elements. Vegetative buffers and screens can also be used to help define spaces and soften the visual impact of buildings, parking areas, and roads. Where horizontal space is limited, fabricated vine-clad vertical fence/wall structures can be used. These 'green screens' are described in more detail in Section 9.4 (Figs. 59 and 60).

Fig. 59. These Eastern Red Cedars will eventually hide these utility boxes from view on ORNL Campus.

ENVIRONMENTAL BENEFITS:

Planting thoughtfully designed vegetative buffers and screens will greatly contribute to the overall aesthetic and environmental quality of the ORNL campus because they:

- Decrease turf/increase biodiversity with pocket habitat plantings
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Showcase native plant communities
- Create habitat and nesting sites for wildlife
- Provide a more diverse food supply for wildlife and insects
- Bring beauty, visual interest, and seasonal variation to the landscape
- Utilize leaves, yard waste, and compost collected and recycled on campus as mulch

Fig. 60. These Hemlocks are hiding a chain link fence from view on ORNL Campus.

AMENITIES:

- Interpretive signs
- Plant identification markers
- Wildlife nesting boxes

RECOMMENDED PLANT PALETTE:

See 12.3 on page 89 for plant list.

9.4 GREEN SCREENS AND WALLS

Green screens (Fig. 61) are modular wire mesh grid systems offering many aesthetic, sustainable, and functional applications such as fences, canopies, partitions and arbors. They are constructed to accommodate climbing plants and vines, and are especially advantageous where horizontal space is limited. There are now several manufacturers offering a variety of materials, styles, and colors.

Green walls accommodate vertical landscapes on building facades, free standing structures, and other impervious vertical surfaces. While vegetation on green screens and walls is typically rooted in the soil, innovative green wall systems are emerging that consist of panels with planting pockets irrigated with recycled water.

Fig. 61. Native vines such as trumpet vine, virginia creeper, and crossvine have been planted. These will eventually climb the panels and screen the view of the parking lot for the users inside.

ENVIRONMENTAL BENEFITS:

Installing green screens and walls will contribute to the overall aesthetic and environmental quality of the ORNL campus because they:

- Showcase native climbing plants and vines
- Attract hummingbirds and butterflies with colorful flowers and nectar
- Provide cover and food for other birds and insects
- Bring beauty, visual interest, and seasonal variation to the landscape
- Provide strategic screening and enclosure in critical locations
- Demonstrate water conservation/reuse in the landscape

AMENITIES:

- Interpretive signs
- Plant identification markers
- Bird feeding stations

RECOMMENDED PLANT PALETTE:

See 12.4 on page 90 for plant list.

9.5 ECOLOGICAL EDGES & NATIVE BOUQUET GARDENS

An ecological edge is the transition zone between turf and woodlands. Typically these interfaces have significant ecological value but also have unique management challenges. These areas are especially prone to invasions of exotic species; thus aggressive invasive removal and proactive encouragement of native plant communities through natural succession and planting is key.

Native bouquet/pollinator gardens are horticulturally maintained plantings of native herbaceous flowering plants and warm season grasses appropriate to site-specific conditions (sun/shade, moist/dry, soil type, etc.). Using native species and avoiding cultivars if possible is encouraged to maximize biodiversity. Regardless of size or scope, these gardens will provide many ecological benefits.

ENVIRONMENTAL BENEFITS:

Transforming turf and invasive exotic infestations into ecological edges can enhance of the environmental and aesthetic value of the landscape because they:

- Decrease turf/increase biodiversity
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Improve water quality by slowing runoff and increasing infiltration more effectively than turf
- Showcase native plant communities
- Create habitat and nesting sites for wildlife
- Provide a more diverse food supply for wildlife and insects
- Bring beauty, visual interest, and seasonal variation to the landscape
- Utilize leaves, yard waste, and compost collected and recycled on campus as mulch

Butterfly Weed

Prairie Coneflower

Above are images of an ecological edge and stream buffer developed recently along First Creek on ORNL Campus.

AMENTITIES:

- Interpretive signs
- Plant identification markers
- Wildlife nesting boxes

RECOMMENDED PLANT PALETTE:

See 12.5 on page 90 for plant list.

The image above shows the same area previously managed as turf.

9.6 BARRENS AND MEADOWS

Among the more unique ecosystems in the Oak Ridge vicinity are cedar barrens. Understanding these distinct landscapes can provide valuable insight into managing disturbed and compacted sites in the built environment. The natural occurrence of cedar barrens is limited to places with thin soil profiles, extreme heat, and drought. Sites on campus with similar conditions are ideal locations for replicating this type of plant community.

Meadows can resemble barrens or zones of old field succession. They, too, are managed plantings of native herbaceous flowering plants and warm season grasses, but are more adaptable to mesic soil conditions than barrens.

Both areas are typically managed by strategic mowing, prescribed burning, or a combination.

ENVIRONMENTAL BENEFITS:

Creating barrens and meadows can enhance sustainability of the ORNL campus because they:

- Decrease turf/increase biodiversity
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Increase worker safety by eliminating mowing/weed-trimming on steep slopes
- Improve water quality by slowing runoff and increasing infiltration more effectively than turf
- Showcase native plant communities
- Create habitat and nesting sites for wildlife
- Attract hummingbirds and butterflies with colorful flowers and nectar
- Provide a more diverse food supply for wildlife and insects
- Bring beauty, visual interest, and seasonal variation to the landscape

AMENITIES:

- Interpretive signs
- Plant identification markers
- Wildlife nesting boxes

RECOMMENDED PLANT PALETTE:

See 12.6 on page 93 for plant list.

The illustration above is a watercolor depicting mature plantings.

(Design and illustration, Environmental Landscape Design Associates)

Watercolor of a native wildflower meadow

Ground layer of a cedar barren plant community in Oak Ridge

Ground layer of a cedar barren plant community in Oak Ridge

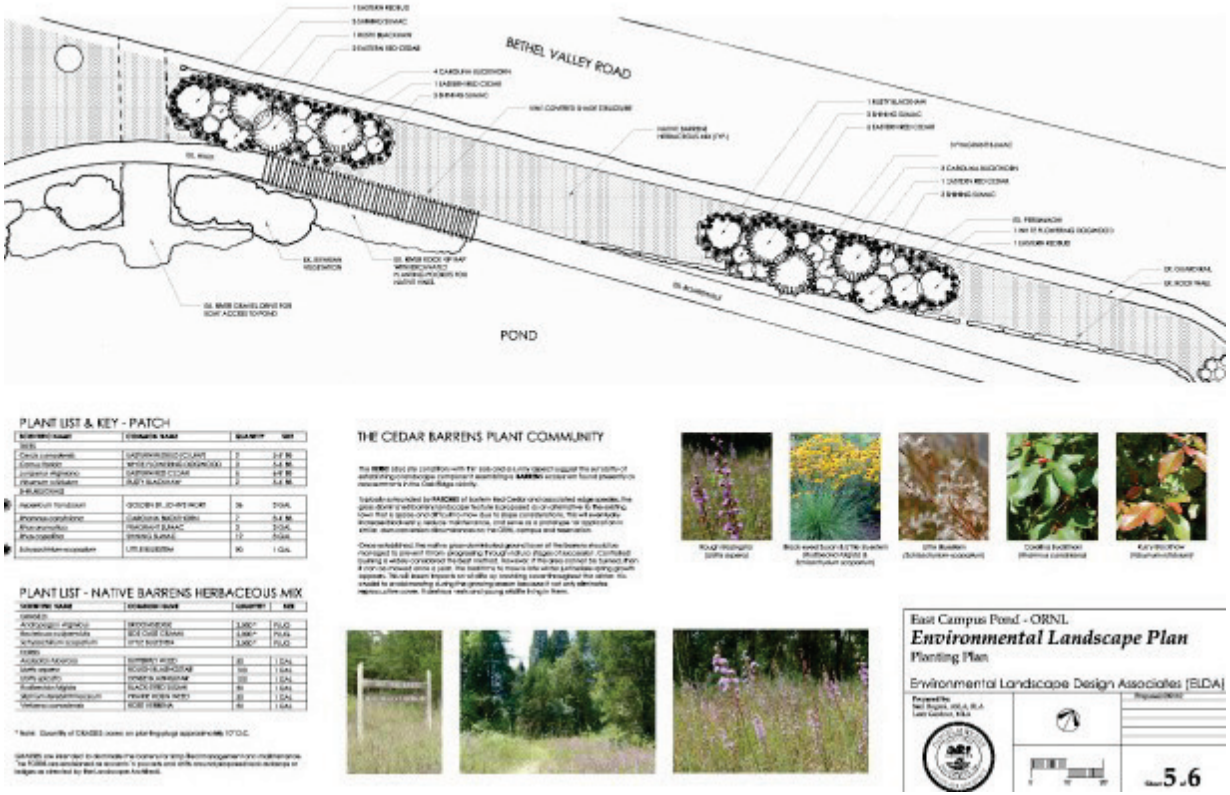
9.7 ECOLOGICAL BEDS AND BORDERS

Ecological beds and borders are horticulturally maintained plantings of native trees, shrubs, groundcovers, herbaceous flowering plants, sedges, and grasses appropriate to site-specific conditions (sun/shade, moist/dry, soil type, etc.). Often these microclimatic variations are affected or created by building development, utilities, roadways, parking, etc.; therefore, it is crucial to analyze and determine the most appropriate plant palette for each area. Using native species and avoiding cultivars if possible is encouraged to maximize biodiversity. Regardless of size or scope, these gardens will provide many ecological benefits.

ENVIRONMENTAL BENEFITS:

Ecologically rich beds and borders in contrast to contrived decorative plantings can enhance sustainability because they:

- Decrease turf/increase biodiversity
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Improve water quality by slowing runoff and increasing infiltration more effectively than turf
- Showcase native plant communities
- Create habitat and nesting sites for wildlife
- Attract hummingbirds and butterflies with colorful flowers and nectar
- Provide a more diverse food supply for wildlife and insects



The landscape design above features a cedar barren plant community, with patches of trees and shrubs and a ground layer of native grasses and wildflowers

(Design and illustration, Environmental Landscape Design Associates)

- Bring beauty, visual interest, and seasonal variation to the landscape
- Utilize leaves, yard waste, and compost recycled as mulch

AMENTITIES:

- Interpretive signs
- Plant identification markers
- Wildlife nesting boxes

RECOMMENDED PLANT PALETTE:

See 12.7 on page 94 for **Sun Mosaic** and **Shade Mosaic** plant lists.

Sun Mosaic featuring Purple Coneflower and Prairie Coneflower

Christmas Fern.

Shade Mosaic featuring Christmas Fern, Wild Columbine, and Woodland Phlox

9.8 LEDGE GARDENS

A ledge garden is a combination of rock ledges, planting pockets for trees and shrubs, and groundcovers on steep areas and stream banks. This concept can potentially serve as a solution to slope transition challenges in the landscape. Ledge gardens can be attractive and naturalistic accents utilizing salvaged rock that would otherwise be destroyed or lost to development. The sense of place is reinforced by replicating limestone rock outcrops prevalent in the Oak Ridge Vicinity.

ENVIRONMENTAL BENEFITS:

- Decrease turf/increase biodiversity
- Reduce erosion by stabilizing slopes with terraced ledges and vegetation
- Improve water quality by slowing runoff and increasing infiltration more effectively than turf
- Shades streams to minimize summer temperatures and retain soil moisture
- Minimize energy use by reducing mowing, weed trimming, and the use of fertilizers
- Increase worker safety by eliminating mowing/weed-trimming on steep slopes
- Create habitat and nesting sites for wildlife
- Provide more diverse food supply for wildlife and insects
- Bring beauty, visual interest, and seasonal variation to the landscape
- Showcase native plant communities
- Showcase salvaged rock demonstrations

Utilize leaves, yard waste, and compost collected and recycled on campus as mulch

AMENITIES:

Interpretive signs

- Plant identification markers
- Wildlife nesting boxes

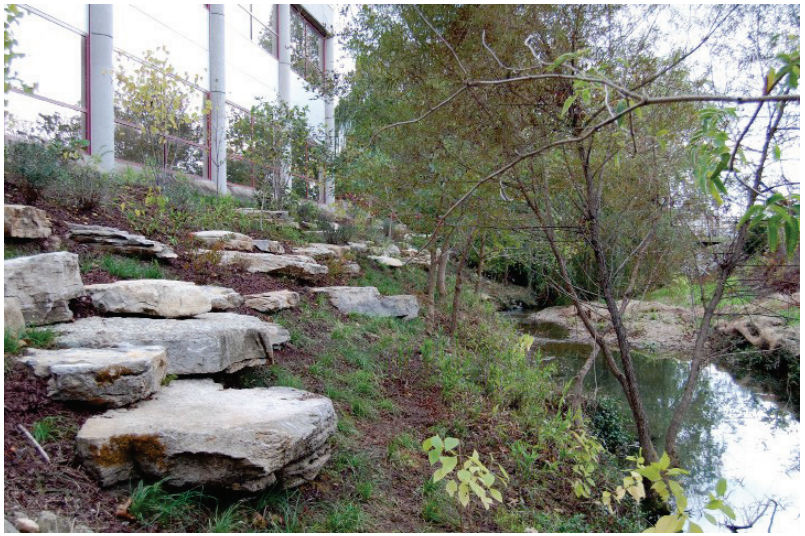
RECOMMENDED PLANT PALETTE:

See 12.8 on page 96 for plant list.

American Beautyberry

River Oats

The rock above was salvaged from a development site and used for this ledge garden at the HTML building on ORNL Campus shown below.



The watercolor illustrates the ledge garden concept and was incorporated into an interpretive sign.

(Design and illustration, Environmental Landscape Design Associates)

10. MANAGEMENT GUIDELINES FOR SUSTAINABLE LANDSCAPES

Landscapes are dynamic systems that present ongoing and seasonal challenges. In the context of the Sustainable Landscapes Initiative, it is recommended that best management practices be established that reflect ORNL's commitment to stewardship and resource conservation. A deeper understanding of landscapes as ecosystems can help guide this effort.

10.1 ENVIRONMENTAL LANDSCAPE MANAGEMENT MINDSET

Landscape management must receive a high level of attention for any sustainable landscape project to be successful. Too often, the term 'sustainable' is perceived as a hands-off approach to landscape maintenance and management. This is erroneous and deserves clarification. 'Sustainable' implies an ethic, not a level of effort, relating to landscape management. The sustainable mindset is one of managing landscape resources that does not negatively impact on-site or off-site resources. Ideally, positive or 'regenerative' enhancements to the environment are spinoff dividends. This is a mindset of nurturing and stewardship, not neglect. Also, the sustainable mindset could include a holistic attention to the environmental resources of the campus, not just landscape projects. Essentially, horticulture and landscape gardening are still very relevant; however, adjustments could be made in traditional practices to better incorporate and blend ecology and natural processes into the grounds maintenance/management culture. While maintenance efforts can be minimized, it is unrealistic to expect quality landscapes in a campus setting without devoting considerable knowledge, training, and resources to the endeavor. Just as 'environmental landscape design' implies creative and artful planning integrated with ecological considerations, 'environmental landscape management' implies landscape maintenance operations that are based on respect for ecological processes over time.

10.2 SUSTAINABLE LANDSCAPE ELEMENTS

Sustainable landscape elements can be classified as the hardscape, softscape, and combinations of the two.

In regard to hardscape elements, special attention could be given to porous paving areas in terms of their long-term need for preventative and periodic care. There is a critical need to care for the porous paving system from installation through time, to avoid clogging, which will compromise its value to the site hydrology. Clogging may result from poor control of sediments from disturbed soils adjacent to the pavers (especially during installation), or from careless stockpiling or use of mulch materials. Short-term, a protection plan could be developed to control critical erosion/sediments/landscape materials during installation. Long-term, organic debris from adjacent trees, plantings, and grass clippings should be swept or blown from the porous pavers periodically, especially in the summer and fall. Decomposed organic fines and soil sediment fines are both problematic for porous paver systems if not properly managed. Such materials can be spread into adjacent softscape areas or incorporated into the compost stream along with other 'yard waste' for reuse and recycling. The amount of fines may be minor, but the need for this maintenance is significant and should be scheduled regularly.

In regard to softscape elements, each of the sustainable landscape prototypes has variations of maintenance/management needs. There are some common guidelines, however, that could be applicable for all prototypes. These include:

- Respect the ecological potential of plant communities, whether they are natural or planted. For example, it is recommended that deadheading associated with grooming of native bouquet/pollinator gardens and ecological edges be timed to maximize the habitat value in early to late fall. Delaying or eliminating this practice may preserve interesting winter textures and stretch seasonal habitat value. While the color and nectar phase in summer has the most visual impact, it is followed by a valuable period of seed and fruit production that especially benefits songbirds. In some locations, deadheading may serve as a good source of seed harvest for in-house propagation of native grasses, sedges, and perennials. Finally, grooming (not manicuring) by conservatively clipping herbaceous materials and pruning trees and shrubs is expected and encouraged in order to maintain aesthetic acceptability, especially in highly visible locations.

- Collect, shred, store, and compost organic debris and yard waste on-site to reuse in landscape restoration and mulched beds. This will minimize the importation of mulch products. Collected leaves can especially be useful to establish a 'duff' layer (decomposing leaf litter) for pocket woodland and ledge garden features.

- Respect and enhance the hydrological patterns and protect water quality. Minimize the use of potable water in landscape irrigation, whether it is temporary or permanent. Conserve and recycle water in the landscape.

- Minimize the use of chemicals in landscape operations, especially pesticides, which may have adverse effects on the food chain for birds, butterflies, amphibians, and fish. Accept and encourage the role of host plants, especially in butterfly gardening, which results in leaves that are partially or entirely devoured by hungry caterpillars.

- Restore the soil by tillage, aeration, texture amendments, and recycled compost. Minimize importation of off-site topsoil.

- Creatively manage natural succession. Not all landscape areas need to be planted. In particular, pocket woodlands and riparian areas can benefit from managing natural succession of native species. Unfortunately, there are challenges to this approach, which are especially addressed in Section 10.3 under the pilot concept known as the 'STEM Zone'.

- Aggressively manage and control pest plants in the landscape.

From common weeds to plants now listed by the state as Invasive Exotic Plants, weeding and pest plant management presents the greatest challenge to gardening and restoring landscapes that feature native plants. Meeting this challenge is discussed further in Sections 10.4 and 11.2.

10.3 STEM ZONE

The acronym STEM usually invokes reference to Science, Technology, Engineering, and Mathematics in the national dialog. However, this acronym has also been useful in recent years to promote an idea that combines ecological landscape management with aesthetic improvement of

edges, utility corridors, and riparian zones in the ORNL campus environment. The concept originated with a couple of projects that had a need to concurrently address both the aesthetic and environmental issues prevalent. Thus, the acronym STEM in the context of landscape management was adopted to refer to the practice of 'Selective Thinning and Exotics Management.' First proposed by Environmental Landscape Design Associates, ecologists at ORNL embraced the idea as a useful way to convey and communicate the practice.

Several considerations have prompted the need for the STEM zone concept. For example, the small streams that interface with the campus have become a haven for invasive exotic plant species. Superabundant native species also populate these corridors and they become intertwined with both native and exotic vines, etc. The appearance becomes 'overgrown', forbidding, and reduces the visual enjoyment of the pleasant stream setting as an amenity. The challenge is therefore balancing the ecological benefits of shade, habitat, and streambank stability with maintaining an improved appearance that is groomed but not overly manicured. Similar analogies may occur in woodland edges that may interface with meadows, lawns or other clearings, wetlands, stormwater detention basins, or ponds.

Thus, successful landscape management requires diligence and vigilance.

Care is needed to identify the various plant populations, to selectively remove certain invasive species, and to occasionally remove or prune native species that may be overcrowded or detract from a desirable view. This diligence requires considerable expertise and an eye for aesthetics. Finally, vigilance is needed to periodically keep up with the dynamics of living, growing, and changing landscapes each year.

In practical terms, flagging is useful that is color coded to denote removal or saving versus pruning, etc. of woody component species. Caution should be exercised in the use of non-selective herbicides that target the entire ground cover layer, especially in riparian zones. It is recommended that this only be done in conjunction with proactive restorative native vegetation strategies coupled with bioengineering fabrics and prevegetated mats, for example, along a stream bank. A rich palette of herbaceous species could be encouraged, not indiscriminately eliminated.

The keys to making the STEM zone concept successful will be knowledge transfer and having a labor force that is willing to learn and embrace the objectives. It can be effective, has great potential in improving the acceptability of the semi-wild areas in the campus interface, and has universal application for areas such as parks, schoolyards, residential communities, nature centers, and greenways throughout the country.

10.4 EXOTIC PEST PLANTS

The Tennessee Exotic Pest Plant Council (TN-EPPC), which was established in 1994, has developed an invasive plant list in Tennessee. In cooperation with Great Smoky Mountains National Park, the organization published the Tennessee Exotic Pest Vegetation Manual in 1997. Since the early years of TN-EPPC, the group has also been instrumental in forming the Southeast

Exotic Pest Council (SE-EPPC), which is now a guiding resource organization for the region. Each of the state organizations maintain reference lists to help raise awareness and initiate management practices to deal with the significant ecological threat of invasive exotic plant species. The purpose of these lists is to identify introduced plant species that are invasive and cause damage to native plant communities. The lists are updated regularly following a rigorous evaluation protocol utilizing input from numerous botanists, ecologists, and resource managers across each state.

In Tennessee, each plant on the state list is ranked based upon the level of threat it presents. The rank definitions are as follows:

Alert: Possess invasive characteristics; known to be invasive in similar habitats as those found in Tennessee

Severe Threat: Possess invasive characteristics; spread easily in native plant communities and displace native vegetation

Significant Threat: Possess invasive characteristics; not presently considered to spread as easily into native plant communities as Severe Threat

Lesser Threat: Spread in or near disturbed areas; not presently considered a threat to native plant communities

Landscape and ecological restoration projects have a much greater chance of success if noxious weeds and invasive plants are removed prior to new plantings. Complementary to the various planting projects is the STEM zone concept (previously discussed) that is equally important. The most effective removal methods will vary for various types of weeds and invasive species; and, best management methods and practices are becoming well established and researched. On-going monitoring and vigilance is necessary to ensure that weeds and invasive plants that are removed do not grow back and their populations are kept in check. This especially requires intensive training of in-house horticultural/grounds personnel combined with contractors competent in the latest and most environmentally acceptable practices. The 2004 *Invasive Plant Management Plan for the Oak Ridge Reservation* is an excellent resource manual.

Overall, the issue of invasive plant management is paramount to a sustainable landscape strategy. It is also presents one of the most challenging aspects of implementing landscapes that emphasize and reinforce native plants and plant communities, whether they are in a campus setting or any place in the region.

11. GENERAL RECOMMENDATIONS AND STRATEGIES

Building on the philosophy, mindset, ethic, and concepts already discussed in this report, additional recommendations are presented in the sections below. These are complementary suggestions relating to landscape support facilities, personnel training, interpretation, and implementation.

11.1 LANDSCAPE SUPPORT FACILITIES

A priority recommendation is to establish improved facilities for campus horticultural operations. These facilities, or complex, should be planned with considerable thought and capital funding to support the Sustainable Landscapes Initiative. It may be important and appropriate to link this complex with some of the native plant and ecological landscape research opportunities mentioned previously. The facilities for campus horticultural operations could include:

- Bulk storage bays
- Equipment sheds
- Greenhouse and nursery compound for propagation and growing plants not readily available from commercial sources in the region
- Secure, irrigated plant holding area available for both in-house and contractor use

The temporary storage facility may be a useful resource to enhance the landscape contractor experience and will be helpful to hold available plants that may be purchased periodically for in-house installation. Having a well maintained holding area for plants would greatly increase the flexibility often needed to reconcile fiscal year procurement issues that do not match the optimum season for planting operations.

Also, within this horticultural services complex could be a modest capability for chipping and shredding brush and organic debris that is generated from various landscape maintenance and utility operations within the ORNL/ORR vicinity. This could include brush from active STEM zone work with the only precaution to preclude invasive exotic plant species seasonally laden with fruits or seeds. This organic material can readily be combined with other leaves and yard waste from campus landscape maintenance to produce acceptable soil amendments and mulch material for reuse on campus. Another sustainability enhancement would be the provision for stockpiling and creatively processing salvaged concrete, rubble, and rock materials for landscape reuse in rain gardens, ledge gardens, and bioengineering mentioned in earlier sections of this report.

Finally, a meeting or conference room within the complex could prove effective in holding periodic workshops and training sessions with the various personnel that are strategic to carrying out an effective stewardship mission of sustainable landscape implementation and management.

11.2 AWARENESS AND PERSONNEL TRAINING

Raising awareness of the Sustainable Landscapes Initiative will involve communicating both broad concepts of sustainability and specific issues related to the green features of the campus. Efforts could enhance the campus community's general knowledge of sustainability and help create a

receptive culture for it. Staff could be exposed to key concepts, be aware of the institution's commitments, and understand their role in maximizing the elements of the green campus.

To increase an understanding of the goals and objectives behind the ORNL Sustainable Landscapes Initiative, efforts could focus on developing partnerships and shared knowledge across campus departments and groups, including:

- Administrators
- Researchers
- Department directors
- Technical organizations
- Support organizations
- Program staff
- Operations staff
- Facility managers

ORNL staff need to understand their role and responsibilities in promoting sustainability on campus. Sustainability is not a one-time endeavor, but an ongoing pursuit to continually improve efforts. Some examples of campus community outreach that could promote sustainability include activities such as periodic newsletters, orientation programs, environmental events and celebrations, and continued communication through the Sustainable Campus website (http://sustainability-ornl.org).

Staff education and training are recommended to provide continuity and long-term success of ORNL's Sustainable Landscapes Initiative. Especially important is the need for skilled employees in the horticultural operations group that are immersed in this ethic and responsibility. Emphasis on this aspect begins with the leadership, but it should also reach each staff member through intensive training, certification in plant identification, and developing an understanding of ecological principles and guidelines. It is recommended that identifying common weeds, native plants, and invasive exotic plants becomes as important as other technical training for staff in other divisions at ORNL.

Although challenging, it is essential that this approach to promoting awareness, educating the campus community, and training staff be followed for the Sustainable Landscapes Initiative to reach its potential. Otherwise landscape efforts will likely be viewed with skepticism for their 'messy' and unkempt appearance. With professional guidance and well-trained grounds and contracted personnel, the Sustainable Landscapes Initiative can serve as a national prototype.

11.3 INTERPRETATION

The ORNL campus presents an opportunity to tell the stories of Oak Ridge National Laboratory and the impact it has had on the world. The ORNL campus is constantly evolving, and the interpretive planning for the campus should also evolve over time. The Sustainable Landscapes Initiative could be integrated into interpretative exhibits and wayfinding.

A combination of media and methodologies are recommended for the ORNL campus. Most of the interpretive media would focus on exterior exhibits and graphics that may be developed along walks, greenway trails, plazas, courtyards, building entrances, parking areas, riparian areas, and other landscape spaces.

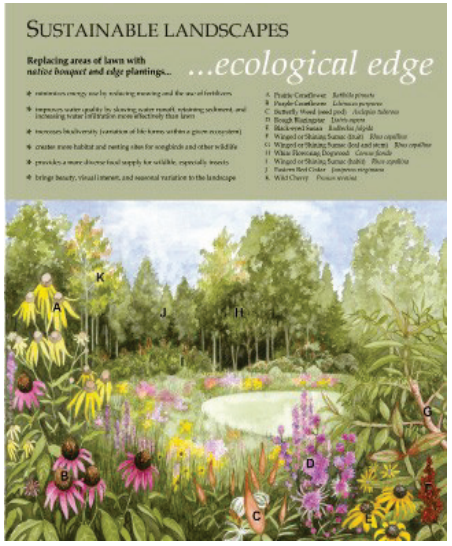
These elements could include:

- Kiosks
- Interpretive graphic panels
- Trailside interpretation
- Plant identification graphics
- Sustainable Landscapes Initiative Project Features
- Ecological/Habitat Education

These elements may take a wide range of different sizes, styles and forms, depending upon their purpose, content, and location. Most of the interpretive features would be permanent, but temporary installations could be used in selected areas to extend the reach and impact.

To facilitate and formalize opportunities for interpretation and wayfinding, a consistent typology of locations and structures could be developed. A clear and consistent system of site identity and wayfinding signage for the campus could include a distinctive and highly recognizable logo or brand. System components could range from relatively large scale signage at designated site entry points to simple directional markers along trails, but all should utilize a common design vocabulary. Interpretive media relating to the Sustainable Landscapes Initiative could build upon identity standards established by previous projects, such as the 'Ecological Edge', 'Rain Garden', and 'Ledge Garden'.

Above and below are interpretive signs developed recently for ORNL



(Design and illustrations, Environmental Landscape Design Associates)

11.4 IMPLEMENTATION STRATEGY

A cohesive implementation strategy is paramount to carrying out the ambitious concepts and plans promoted in this report. Defining roles and expectations of the campus partners in this endeavor would be useful in focusing attention on the need to clarify and improve the

Sustainable Landscapes Initiative, which is already underway. Key collaborators include:

- The ORNL Landscape Committee
- Campus Landscape Architect (proposed)
- Design Consultants
- Horticultural/Grounds Operations Personnel
- Landscape Contractors
- Project Managers and Engineers
- Procurement Personnel

With the campus serving as a living laboratory for landscape research and implementation, ORNL would be able to demonstrate that it is at the forefront of society with environmental leadership and sustainable living practices. Efforts can be enhanced and recognized by participation in programs such as LEED certification for buildings and the SITES rating system for sustainable landscapes. An annual reporting system could help monitor progress and keep stakeholders informed. ORNL could establish continual tracking and reporting mechanisms to ensure goals of the Sustainable Landscapes Initiative are being met.

ORNL's successful sustainability plan can have a positive impact on the local community, region, and the nation. As a significant landholder and employer, ORNL has a tremendous economic, fiscal and physical impact on local infrastructure and resources. Creating a green campus demonstrates a commitment to environmental sustainability and can potentially serve as a model for other institutions nationally and internationally.

An interpretive sign developed recently for ORNL

(Design and illustrations, Environmental Landscape Design Associates)

12. RECOMMENDED PLANT LISTS

12.1 DESIGN CONCEPTS FOR MANAGING STORMWATER

12.1.1 Stream Buffers

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Acer rubrum	Red Maple	up/low
Betula nigra	River Birch	low
Carya ovata	Shagbark Hickory	up
Celtis occidentalis	Hackberry	up/low
Cladrastis lutea	American Yellowwood	up
Diospyros virginiana	Persimmon	up
Fagus grandifolia	American Beech	up/low
Juniperus virginiana	Eastern Red Cedar	up
Liquidambar styraciflua	Sweetgum	up/low
Liriodendron tulipifera	Tulip Poplar	up/low
Morus rubra	Red Mulberry	up/low
Nyssa sylvatica	Blackgum	up/low
Pinus strobus	White Pine	up
Pinus echinata	Shortleaf Pine	up
Pinus taeda	Loblolly Pine	up
Pinus virginiana	Virginia Pine	up
Platanus occidentalis	Sycamore	low
Prunus serotina	Wild Black Cherry	up/low
Quercus bicolor	Swamp White Oak	low
Quercus shumardii	Shumard Oak	up/low
Salix nigra	Black Willow	low
Ulmus alata	Winged Elm	up/low
Ulmus americana	American Elm	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
SUB-CANOPY/ACCENT TREES		
Aesculus pavia	Red Buckeye	up/low
Alnus serrulata	Stream Alder	low
Amelanchier arborea	Common Serviceberry	up/low
Amelanchier laevis	Allegheny Serviceberry	up/low
Asimina triloba	Pawpaw	low

Scientific Name	Common Name	Upland/Lowland
Carpinus caroliniana	Ironwood	up
Cercis canadensis	Eastern Redbud	up
Chionanthus virginicus	Fringetree	up/low
Cornus florida	White Dogwood	up
Crataegus crusgalli	Cockspur Hawthorn	up
Crataegus phaenopyrum	Washington Hawthorn	up
Hamamelis virginiana	Witchhazel	up/low
Ilex opaca	American Holly	up/low
Ostrya virginiana	Hophornbeam	up
Rhamnus caroliniana	Carolina Buckthorn	up/low
Rhus glabra	Smooth Sumac	up
Viburnum prunifolium	Blackhaw	up/low
Viburnum rufidulum	Rusty Blackhaw	up

Scientific Name	Common Name	Upland/Lowland
SHRUBS		
Amorpha fruticosa	Indigobush	low
Callicarpa americana	American Beautyberry	up/low
Calycanthus floridus	Sweetshrub	up/low
Ceanothus americanus	New Jersey Tea	up
Cephalanthus occidentalis	Buttonbush	low
Clethra alnifolia	Summersweet	low
Cornus amomum	Silky Dogwood	low
Corylus americana	American Hazelnut	up/low
Euonymus americanus	Hearts-a-bustin’	low
Hydrangea quercifolia	Oakleaf Hydrangea	up/low
Hypericum frondosum	Golden St. John’s Wort	up/low
Hypericum prolificum	Shrubby St. John’s Wort	up
Ilex verticillata	Winterberry	low
Itea virginica	Virginia Sweetspire	low
Photinia melanocarpa	Black Chokeberry	up/low
Photinia pyrifolia	Red Chokeberry	up/low
Physocarpus opulifolius	Common Ninebark	up
Rhus aromatica	Fragrant Sumac	up
Rhus copallina	Shining/Winged Sumac	up
Sambucus canadensis	Elderberry	low
Symphoricarpos orbiculatus	Coralberry	up/low

Scientific Name	Common Name	Upland/Lowland
FORBS		
Amsonia tabernaemontana	Eastern Bluestar	up/low
Aquilegia canadensis	Wild Columbine	up/low
Asclepias incarnata	Swamp Milkweed	low
Conoclinium coelestinum	Wild Ageratum	low
Eupatorium fistulosum	Joe-pye Weed	low
Hibiscus moscheutos	Rose Mallow	low
Impatiens capensis	Jewel Weed	low
Lobelia cardinalis	Cardinal Flower	low
Lobelia syphilitica	Big Blue Lobelia	low
Monarda didyma	Beebalm	low
Monarda fistulosa	Wild Bergamot	up/low
Rudbeckia triloba	Brown-eyed Susan	low
Symphiotrichum oblongifolium	Aromatic Aster	up/low
Tradescantia virginica	Spiderwort	up/low
Vernonia gigantea	Ironweed	low
Scientific Name	**Common Name**	**Upland/Lowland**
GRASSES/SEDGES		
Andropogon glomeratus	Wooly/Bushy Broomsedge	low
Arundinaria gigantea	River Cane	low
Carex cherokeensis	Cherokee Sedge	up/low
Chasmanthium latifolium	River Oats	up/low
Elymus virginicus	Virginia Wild Rye	low
Scientific Name	**Common Name**	**Upland/Lowland**
FERNS		
Adiantum pedatum	Maidenhair Fern	low
Athyrium filix-femina	Lady Fern	low
Osmunda cinnamomea	Cinnamon Fern	low
Osmunda regalis	Royal Fern	low
Polystichum acrostichoides	Christmas Fern	up/low
Pteridium aquilinum	Bracken Fern	up/low

12.1.2 Pocket Wetlands, Bogs, and Detention/Retention Basins

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Recommended for accent plantings along wetland perimeter		
Acer rubrum	Red Maple	up/low
Betula nigra	River Birch	low
Diospyros virginiana	Persimmon	up
Liquidambar styraciflua	Sweetgum	up/low
Morus rubra	Red Mulberry	up/low
Platanus occidentalis	Sycamore	low
Prunus serotina	Wild Black Cherry	up/low
Quercus bicolor	Swamp White Oak	low
Quercus shumardii	Shumard Oak	up/low
Salix nigra	Black Willow	low
Scientific Name	**Common Name**	**Upland/Lowland**
SUB-CANOPY/ACCENT TREES		
Recommended for accent plantings along wetland perimeter		
Aesculus pavia	Red Buckeye	up/low
Alnus serrulata	Stream Alder	low
Amelanchier arborea	Common Serviceberry	up/low
Amelanchier laevis	Allegheny Serviceberry	up/low
Chionanthus virginicus	Fringetree	up/low
Hamamelis virginiana	Witchhazel	up/low
Rhamnus caroliniana	Carolina Buckthorn	up/low
Viburnum prunifolium	Blackhaw	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
SHRUBS		
Recommended for accent plantings along wetland perimeter		
Amorpha fruticosa	Indigobush	low
Callicarpa americana	American Beautyberry	up/low
Cephalanthus occidentalis	Buttonbush	low
Clethra alnifolia	Summersweet	low
Cornus amomum	Silky Dogwood	low
Corylus americana	American Hazelnut	up/low
Euonymus americanus	Hearts-a-bustin’	low
Hypericum frondosum	Golden St. John’s Wort	up/low
Ilex verticillata	Winterberry	low

Scientific Name	Common Name	Upland/Lowland
Itea virginica	Virginia Sweetspire	low
Photinia melanocarpa	Black Chokeberry	up/low
Photinia pyrifolia	Red Chokeberry	up/low
Rosa palustris	Swamp Rose	low
Sambucus canadensis	Elderberry	low
Scientific Name	**Common Name**	**Upland/Lowland**
FORBS		
Recommended for accent plantings along wetland perimeter		
Asclepias incarnata	Swamp Milkweed	low
Conoclinium coelestinum	Wild Ageratum	low
Eupatorium fistulosum	Joe-pye Weed	low
Impatiens capensis	Jewel Weed	low
Lobelia cardinalis	Cardinal Flower	low
Lobelia syphilitica	Big Blue Lobelia	low
Monarda didyma	Beebalm	low
Rudbeckia triloba	Brown-eyed Susan	up/low
Symphiotrichum oblongifolium	Aromatic Aster	up/low
Tradescantia virginica	Spiderwort	up/low
Vernonia gigantea	Ironweed	low
Scientific Name	**Common Name**	**Upland/Lowland**
GRASSES/SEDGES		
Recommended for accent plantings along wetland perimeter		
Andropogon glomeratus	Wooly/Bushy Broomsedge	low
Arundinaria gigantea	River Cane	low
Carex cherokeensis	Cherokee Sedge	up/low
Chasmanthium latifolium	River Oats	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
FERNS		
Recommended for accent plantings along wetland perimeter		
Adiantum pedatum	Maidenhair Fern	low
Athyrium filix-femina	Lady Fern	low
Osmunda cinnamomea	Cinnamon Fern	low
Osmunda regalis	Royal Fern	low
Polystichum acrostichoides	Christmas Fern	up/low
Pteridium aquilinum	Bracken Fern	up/low

Scientific Name	Common Name	Upland/Lowland
AQUATIC PLANTS		
Alisma subcordata	Water Plantain	low
Eleocaharis spp.	Spikerush	low
Equisetum arvense	Field Horsetail	up/low
Equisetum hyemale	Scouring Rush	up/low
Hibiscus laevis	Halberd-leaved Mallow	up/low
Hibiscus moscheutos	Swamp Rose Mallow	up/low
Nelumbo lutea	American lotus	low
Juncus effusus	Soft Rush	low
Nuphar lutea	Spadderdock	low
Pontederia cordata	Pickerelweed	low
Sagittaria latifolia	Arrowhead	low
Saururus cernuus	Lizard's Tail	low
Scirpus cyperinus	Woolgrass	low
Typha latifolia	Broad-leaf Cattail	low

12.1.3 Raingardens and Bioswales

Scientific Name	Common Name	Upland/Lowland
SHRUBS		
Recommended for accent/edge plantings along rain garden perimeter		
Amorpha fruticosa	Indigobush	low
Callicarpa americana	American Beautyberry	up/low
Calycanthus floridus	Sweetshrub	up/low
Cephalanthus occidentalis	Buttonbush	low
Clethra alnifolia	Summersweet	low
Cornus amomum	Silky Dogwood	low
Corylus americana	American Hazelnut	up/low
Euonymus americanus	Hearts-a-bustin'	low
Hypericum frondosum	Golden St. John's Wort	up/low
Ilex verticillata	Winterberry	low
Itea virginica	Virginia Sweetspire	up/low
Photinia melanocarpa	Black Chokeberry	up/low
Photinia pyrifolia	Red Chokeberry	up/low
Sambucus canadensis	Elderberry	low

Scientific Name	Common Name	Upland/Lowland
FORBS		
Amsonia tabernaemontana	Eastern Bluestar	up/low
Aquilegia canadensis	Wild Columbine	up/low
Asclepias incarnata	Swamp Milkweed	low
Conoclinium coelestinum	Wild Ageratum	low
Eupatorium fistulosum	Joe-pye Weed	low
Hibiscus moscheutos	Rose Mallow	low
Impatiens capensis	Jewel Weed	low
Lobelia cardinalis	Cardinal Flower	low
Lobelia syphilitica	Big Blue Lobelia	low
Monarda didyma	Beebalm	low
Monarda fistulosa	Wild Bergamot	up/low
Rudbeckia triloba	Brown-eyed Susan	low
Symphiotrichum oblongifolium	Aromatic Aster	up/low
Tradescantia virginica	Spiderwort	up/low
Vernonia gigantea	Ironweed	low
Scientific Name	**Common Name**	**Upland/Lowland**
GRASSES/SEDGES/RUSHES		
Andropogon glomeratus	Wooly/Bushy Broomsedge	low
Arundinaria gigantea	River Cane	low
Carex cherokeensis	Cherokee Sedge	up/low
Chasmanthium latifolium	River Oats	up/low
Juncus effusus	Soft Rush	low
Scientific Name	**Common Name**	**Upland/Lowland**
FERNS		
Adiantum pedatum	Maidenhair Fern	low
Athyrium filix-femina	Lady Fern	low
Osmunda cinnamomea	Cinnamon Fern	low
Osmunda regalis	Royal Fern	low
Polystichum acrostichoides	Christmas Fern	up/low
Pteridium aquilinum	Bracken Fern	up/low

12.2 POCKET WOODLANDS AND WOODLAND ZONES

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Acer rubrum	Red Maple	up/low
Acer saccharum	Sugar Maple	up/low
Betula nigra	River Birch	low
Celtis occidentalis	Hackberry	up/low
Carya glabra	Pignut Hickory	up
Carya ovata	Shagbark Hickory	up
Carya tomentosa	Mockernut Hickory	up
Diospyros virginiana	Persimmon	up
Fagus grandifolia	American Beech	up/low
Juniperus virginiana	Eastern Red Cedar	up
Liquidambar styraciflua	Sweetgum	up/low
Liriodendron tulipifera	Tulip Poplar	up/low
Morus rubra	Red Mulberry	up/low
Nyssa sylvatica	Blackgum	up
Pinus echinata	Shortleaf Pine	up
Pinus strobus	White Pine	up
Pinus taeda	Loblolly Pine	up
Pinus virginiana	Virginia Pine	up
Platanus occidentalis	Sycamore	low
Prunus serotina	Wild Black Cherry	up/low
Quercus alba	White Oak	up
Quercus coccinea	Scarlet Oak	up
Quercus falcata	Southern Red Oak	up
Quercus palustris	Pin Oak	up/low
Quercus phellos	Willow Oak	up/low
Quercus prinus	Chestnut Oak	up
Quercus rubra	Red Oak	up
Quercus shumardii	Shumard Oak	up/low
Quercus stellata	Post Oak	up
Sassafras albidum	Sassafras	up
Tilia americana	Basswood	up/low
Tsuga canadensis	Eastern Hemlock	up/low
Ulmus alata	Winged Elm	up/low
Ulmus americana	American Elm	up/low

Scientific Name	Common Name	Upland/Lowland
SUB-CANOPY/ACCENT TREES		
Recommended for accent plantings along edges of woodlands for seasonal interest and wildlife value		
Aesculus pavia	Red Buckeye	low
Amelanchier arborea	Common Serviceberry	up/low
Amelanchier laevis	Allegheny Serviceberry	up/low
Aralia spinosa	Devil's Walking Stick	up/low
Asimina triloba	Pawpaw	low
Carpinus caroliniana	Ironwood	low
Cercis canadensis	Eastern Redbud	up
Cornus florida	White Dogwood	up
Chionanthus virginicus	Fringetree	up/low
Cladrastis lutea	American Yellowwood	up/low
Crataegus crus-galli	Cockspur Hawthorn	up
Crataegus phaenopyrum	Washington Hawthorn	up
Halesia tetraptera	Silverbell	up/low
Hamamelis virginiana	Witchhazel	up/low
Ilex opaca	American Holly	up/low
Ostrya virginiana	Hophornbeam	up
Oxydendrum arboreum	Sourwood	up
Rhamnus caroliniana	Carolina Buckthorn	up/low
Rhus copallina	Shining/Winged Sumac	up
Rhus glabra	Smooth Sumac	up
Viburnum prunifolium	Blackhaw	up/low
Viburnum rufidulum	Rusty Blackhaw	up

12.3 VEGETATIVE BUFFERS AND SCREENS

Scientific Name	Common Name	Upland/Lowland
EVERGREEN TREES		
Ilex opaca	American Holly	up/low
Juniperus virginiana	Eastern Red Cedar	up
Magnolia virginiana	Sweetbay Magnolia	low
Pinus strobus	White Pine	up
Pinus taeda	Loblolly Pine	up
Pinus virginiana	Virginia Pine	up

Scientific Name	Common Name	Upland/Lowland
SUB-CANOPY/ACCENT TREES		
Recommended for accent plantings along edges of evergreen masses for seasonal interest and wildlife value		
Cercis canadensis	Eastern Redbud	up
Chionanthus virginicus	Fringetree	up/low
Cornus florida	White Dogwood	up
Crataegus crusgalli	Cockspur Hawthorn	up
Crataegus phaenopyrum	Washington Hawthorn	up
Rhamnus caroliniana	Carolina Buckthorn	up/low
Rhus glabra	Smooth Sumac	up
Viburnum prunifolium	Blackhaw	up/low
Viburnum rufidulum	Rusty Blackhaw	up
Scientific Name	**Common Name**	**Upland/Lowland**
SHRUBS		
Recommended for accent plantings along edges of evergreen masses for seasonal interest and wildlife value		
Callicarpa americana	American Beautyberry	up/low
Calycanthus floridus	Sweetshrub	up/low
Hypericum prolificum	Shrubby St. John's Wort	up
Rhus aromatica	Fragrant Sumac	up
Rhus copallina	Shining/Winged Sumac	up
Symphoricarpos orbiculatus	Coralberry	up/low
Arundinaria gigantea	River Cane	low
Scientific Name	**Common Name**	**Upland/Lowland**
GRASSES		
Andropogon gerardii	Big Bluestem	up
Arundinaria gigantea	River Cane	low
Panicum virgatum	Switchgrass	up
Saccharum giganteum	Sugarcane Plumegrass	up
Schyzachyrium scoparium	Little Bluestem	up
Sorghastrum nutans	Indian Grass	up

12.4 GREEN SCREENS AND WALLS

Scientific Name	Common Name	Upland/Lowland
VINES		
Bignonia capreolata	Crossvine	up/low
Campsis radicans	Trumpet Creeper	up/low
Clematis virginiana	Virgins Bower	low
Clematis viorna	Leatherflower	up/low
Lonicera sempervirens	Coral Honeysuckle	up/low
Parthenocissus quinquefolia	Virginia Creeper	up/low
Passiflora incarnata	Passionflower	up/low
Rosa setigera	Climbing Prairie Rose	up
Wisteria frutescens	American Wisteria	up/low

12.5 ECOLOGICAL EDGES AND NATIVE BOUQUET/POLLINATOR GARDENS

12.5.1 Ecological Edges

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Recommended for accent planting along woodland edge of transitions zones, and not in herbaceous/grass areas		
Acer rubrum	Red Maple	up/low
Celtis occidentalis	Hackberry	up/low
Diospyros virginiana	Persimmon	up
Juniperus virginiana	Eastern Red Cedar	up
Liquidambar styraciflua	Sweetgum	up/low
Morus rubra	Red Mulberry	up/low
Prunus serotina	Wild Black Cherry	up/low
Sassafras albidum	Sassafras	up/low
Ulmus alata	Winged Elm	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
SUB-CANOPY/ACCENT TREES		
Recommended for accent planting along woodland edge of transitions zones, and not in herbaceous/grass areas		
Aesculus pavia	Red Buckeye	low

Scientific Name	Common Name	Upland/Lowland
Amelanchier arborea	Common Serviceberry	up/low
Amelanchier laevis	Allegheny Serviceberry	up/low
Aralia spinosa	Devil's Walking Stick	up/low
Asimina triloba	Pawpaw	low
Cercis canadensis	Eastern Redbud	up
Chionanthus virginicus	Fringetree	up/low
Cornus florida	White Dogwood	up
Crataegus crusgalli	Cockspur Hawthorn	up
Crataegus phaenopyrum	Washington Hawthorn	up
Ilex opaca	American Holly	up/low
Prunus americana	Wild Plum	up
Rhamnus caroliniana	Carolina Buckthorn	up/low
Rhus glabra	Smooth Sumac	up
Viburnum rufidulum	Rusty Blackhaw	up
Scientific Name	**Common Name**	**Upland/Lowland**
SHRUBS		
Recommended for accent planting along woodland edge of transitions zones, and not in herbaceous/grass areas		
Callicarpa americana	American Beautyberry	up/low
Calycanthus floridus	Sweetshrub	up/low
Ceanothus americanus	New Jersey Tea	up
Corylus americana	American Hazelnut	up/low
Hydrangea quercifolia	Oakleaf Hydrangea	up/low
Hypericum prolificum	Shrubby St. John's Wort	up
Physocarpus opulifolius	Common Ninebark	up
Rhus aromatica	Fragrant Sumac	up
Rhus copallina	Shining/Winged Sumac	up
Symphoricarpos orbiculatus	Coralberry	up/low

12.5.2 Native Bouquet/Pollinator Gardens

Scientific Name	Common Name	Upland/Lowland
HERBACEOUS		
Amsonia tabernaemontana	Eastern Bluestar	up/low
Aquilegia canadensis	Wild Columbine	up/low
Asclepias tuberosa	Butterfly Weed	up

Scientific Name	Common Name	Upland/Lowland
Baptisia australis	Blue Wild Indigo	up/low
Coreopsis auriculata	Mouse-eared Coreopsis	up
Coreopsis lanceolata	Lance-leaved Coreopsis	up
Echinacea pupurea	Purple Coneflower	up
Eupatorium fistulosum	Joe-pye Weed	low
Eurybia divaricata	White Wood Aster	up
Liatris aspera	Rough Blazing Star	up
Liatris cylindracea	Ontario Blazing Star	up
Liatris spicata	Dense Blazing Star	up
Liatris squarrosa	Scaly Blazing Star	up
Monarda didyma	Beebalm	low
Monarda fistulosa	Wild Bergamot	up/low
Penstemon digitalis	White Beardstongue	up
Phlox paniculata	Summer Phlox	up
Ratibida pinnata	Prairie Coneflower	up
Rudbeckia fulgida	Black-eyed Susan	up
Rudbeckia hirta	Black-eyed Susan	up
Symphyotrichum cordifolium	Blue Wood Aster	up
Symphyotrichum novae-angliae	New England Aster	up/low
Symphyotrichum oblongifolium	Aromatic Aster	up/low
Tradescantia virginica	Spiderwort	up/low
Vernonia gigantea	Ironweed	low
Scientific Name	**Common Name**	**Upland/Lowland**
GRASSES		
Eragrostis spectabilis	Purple Lovegrass	up
Schyzachyrium scoparium	Little Bluestem	up

12.6 BARRENS AND MEADOWS

12.6.1 Barrens

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Carya glabra	Shagbark Hickory	up
Diospyros virginiana	Persimmon	up
Juniperus virginiana	Eastern Red Cedar	up

Scientific Name	Common Name	Upland/Lowland
Pinus virginiana	Virginia Pine	up
Ulmus alata	Winged Elm	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
SUB-CANOPY/ACCENT TREES		
Cercis canadensis	Eastern Redbud	up
Cornus florida	White Flowering Dogwood	up
Rhamnus caroliniana	Carolina Buckthorn	up/low
Viburnum rufidulum	Rusty Blackhaw	up
Scientific Name	**Common Name**	**Upland/Lowland**
SHRUBS		
Hypericum frondosum	Golden St. John's Wort	up
Rhus aromatica	Fragrant Sumac	up
Rhus copallina	Shining/Winged Sumac	up
Scientific Name	**Common Name**	**Upland/Lowland**
FORBS		
Helianthus occidentalis	Western Sunflower	up
Liatris aspera	Rough Blazingstar	up
Liatris spicata	Dense Blazingstar	up
Liatris squarrosa	Scaly Blazingstar	up
Opuntia humifusa	Prickly Pear	up
Pycnanthemum torrei	Torry's Mountain Mint	up
Solidago ptarmicoides	Prairie Goldenrod	up
Silphium terebinthenaceum	Prairie Dock	up
Scientific Name	**Common Name**	**Upland/Lowland**
GRASSES		
Adropogon gerardii	Big Bluestem	up
Bouteloua cutipendula	Side-oats Grama	up
Schizachyrium scoparium	Little Bluestem	up
Sorghastrum nutans	Indian Grass	up

12.6.2 Meadows

Scientific Name	Common Name	Upland/Lowland
FORBS		
Asclepias incarnata	Swamp Milkweed	low
Asclepias syriaca	Common Milkweed	up
Asclepias tuberosa	Butterfly Weed	up
Baptisia australis	Blue Wild Indigo	up/low
Conoclinium coelestinum	Wild Ageratum	low
Coreopsis lanceolata	Lance-leaved Coreopsis	up
Echinacea pupurea	Purple Coneflower	up
Eupatorium fistulosum	Joe-pye Weed	low
Helianthus angustifolius	Swamp Sunflower	low
Liatris aspera	Rough Blazing Star	up
Liatris cylindracea	Ontario Blazing Star	up
Liatris spicata	Dense Blazing Star	up
Liatris squarrosa	Scaly Blazing Star	up
Lobelia cardinalis	Cardinal Flower	low
Lobelia syphilitica	Big Blue Lobelia	low
Monarda didyma	Beebalm	low
Monarda fistulosa	Wild Bergamot	up/low
Penstemon digitalis	White Beardstongue	up
Phlox paniculata	Summer Phlox	up
Ratibida pinnata	Prairie Coneflower	up
Rudbeckia fulgida	Black-eyed Susan	up
Rudbeckia hirta	Black-eyed Susan	up
Solidago spp.	Goldenrod	up/low
Symphyotrichum novae-angliae	New England Aster	up/low
Symphyotrichum oblongifolium	Aromatic Aster	up/low
Vernonia gagantea	Ironweed	low
Scientific Name	**Common Name**	**Upland/Lowland**
GRASSES		
Andropogon gerardii	Big Bluestem	up
Andropogon glomeratus	Wooly/Bushy Broomsedge	low
Andropogon ternarius	Splitbeard Bluestem	up
Andropogon virginicus	Broomsedge	up
Eragrostis spectabilis	Purple Lovegrass	up
Schyzachyrium scoparium	Little Bluestem	up

12.7 ECOLOGICAL BEDS AND BORDERS

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Acer rubrum	Freeman Maple	up/low
Acer saccharum	Sugar Maple	up/low
Betula nigra	River Birch	low
Carya glabra	Pignut Hickory	up
Carya ovata	Shagbark Hickory	up
Carya tomentosa	Mockernut Hickory	up
Fagus grandifolia	American Beech	up/low
Liriodendron tulipifera	Tulip Poplar	up/low
Juniperus virginiana	Eastern Red Cedar	up
Liquidambar styraciflua	Sweetgum	up/low
Nyssa sylvatica	Blackgum	up/low
Sassafras albidum	Sassafras	up/low
Ulmus alata	Winged Elm	up/low
Quercus alba	White Oak	up
Quercus coccinea	Scarlet Oak	up
Quercus falcata	Southern Red Oak	up
Quercus palustris	Pin Oak	up/low
Quercus phellos	Willow Oak	up/low
Quercus prinus	Chestnut Oak	up
Scientific Name	**Common Name**	**Upland/Lowland**
SUB-CANOPY/ACCENT TREES		
Aesculus pavia	Red Buckeye	up/low
Amelanchier arborea	Common Serviceberry	up/low
Amelanchier laevis	Allegheny Serviceberry	up/low
Asimina triloba	Pawpaw	low
Cercis canadensis	Eastern Redbud	up
Chionanthus virginicus	Fringetree	up/low
Cladrastus lutea	American Yellowwood	up/low
Cornus florida	White Dogwood	up
Crataegus crusgalli	Cockspur Hawthorn	up
Crataegus phaenopyrum	Washington Hawthorn	up
Halesia tetraptera	Silverbell	up/low
Ilex opaca	American Holly	up/low
Rhamnus caroliniana	Carolina Buckthorn	up/low

Scientific Name	Common Name	Upland/Lowland
Rhus glabra	Smooth Sumac	up
Viburnum rufidulum	Rusty Blackhaw	up

12.7.1 Sun Mosaic

Scientific Name	Common Name	Upland/Lowland
SHRUBS		
Ceanothus americanus	New Jersey Tea	up
Cephalanthus occidentalis	Buttonbush	low
Clethra alnifolia	Summersweet	low
Fothergilla major	Fothergilla	up/low
Hypericum frondosum	Golden St. John's Wort	up
Ilex verticillata	Winterberry	low
Itea virginica	Virginia Sweetspire	low
Photinia melanocarpa	Black Chokeberry	up/low
Photinia pyrifolia	Red Chokeberry	up/low
Rosa carolina	Carolina Rose	up
Rosa palustris	Swamp Rose	low
Scientific Name	**Common Name**	**Upland/Lowland**
FORBS		
Amsonia tabernaemontana	Eastern Bluestar	up/low
Asclepias tuberosa	Butterfly Weed	up
Baptisia australis	Blue Wild Indigo	up/low
Coreopsis auriculata	Mouse-eared Coreopsis	up
Coreopsis lanceolata	Lance-leaved Coreopsis	up
Liatris aspera	Rough Blazing Star	up
Liatris spicata	Dense Blazing Star	up
Liatris squarrosa	Scaly Blazing Star	up
Monarda fistulosa	Wild Bergamot	up/low
Penstemon digitalis	White Beardstongue	up
Pteridium aquilinum	Bracken Fern	up/low
Phlox paniculata	Summer Phlox	up
Ratibida pinnata	Prairie Coneflower	up
Rudbeckia fulgida	Black-eyed Susan	up
Rudbeckia hirta	Black-eyed Susan	up
Schyzachyrium scoparium	Little Bluestem	up

Scientific Name	Common Name	Upland/Lowland
Symphyotrichum novae-angliae	New England Aster	up/low
Symphyotrichum oblongifolium	Aromatic Aster	up/low

12.7.2 Shade Mosaic

Scientific Name	Common Name	Upland/Lowland
SHRUBS		
Callicarpa americana	American Beautyberry	up/low
Calycanthus floridus	Sweetshrub	up/low
Euonymus americanus	Hearts-a-bustin'	low
Hydrangea arborescens	Wild Hydrangea	up/low
Hydrangea quercifolia	Oakleaf Hydrangea	up/low
Itea virginica	Virginia Sweetspire	up/low
Lindera benzoin	Spicebush	up/low
Symphoricarpos orbiculatus	Coralberry	up/low
Viburnum acerifolium	Maple leaf Viburnum	up
Viburnum dentatum	Arrowwood Viburnum	low
Scientific Name	**Common Name**	**Upland/Lowland**
FORBS		
Antennaria plantaginifolia	Pussy Toes	up
Aquilegia canadensis	Wild Columbine	up/low
Asarum canadense	Wild Ginger	up
Carex cherokeensis	Cherokee Sedge	up/low
Carex pennsylvanica	Pennsylvania Sedge	up
Chasmanthium latifolium	River Oats	up/low
Eurybia divaricata	White Wood Aster	up
Geranium maculatum	Wild Geranium	up
Heuchera Americana	Alumroot	up/low
Hypericum hypericoides	St. Andrew's Cross	up
Iris cristata	Dwarf Crested Iris	up/low
Mertensia virginica	Virginia Bluebells	low
Pachysandra procumbens	Allegheny Spurge	up
Phlox divaricata	Woodland Phlox	up/low
Polygonatum biflorum	Solomon's Seal	up/low
Polystichum acrostichoides	Christmas Fern	up/low
Smilacina racemosa	False Solomon's Seal	up/low

Scientific Name	Common Name	Upland/Lowland
Symphyotrichum cordifolium	Blue Wood Aster	up
Spigelia marilandica	Indian Pink	low
Tradescantia virginica	Spiderwort	up/low

12.8 LEDGE GARDENS

Ledge Garden with Protected Aspect: Part sun/shade, North and East facing slopes

Example: A (partly) wooded stream bank with moist soils near the water and drier soils uphill

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Acer rubrum	Red maple	up/low
Betula nigra	River Birch	low
Carya ovata	Shagbark Hickory	up
Celtis occidentalis	Hackberry	up/low
Cladrastis lutea	American Yellowwood	up
Diospyros virginiana	Persimmon	up
Fagus grandifolia	American Beech	up/low
Liquidambar styraciflua	Sweetgum	up/low
Liriodendron tulipifera	Tulip Poplar	up/low
Morus rubra	Red Mulberry	up/low
Nyssa sylvatica	Blackgum	up/low
Pinus strobus	White Pine	up
Platanus occidentalis	Sycamore	low
Prunus serotina	Wild Black Cherry	up/low
Quercus bicolor	Swamp White Oak	low
Quercus shumardii	Shumard Oak	up/low
Ulmus alata	Winged Elm	up/low
Ulmus americana	American Elm	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
SUB-CANOPY TREES		
Aesculus pavia	Red Buckeye	up/low
Alnus serrulata	Stream Alder	low
Amelanchier arborea	Common Serviceberry	up/low
Amelanchier laevis	Allegheny Serviceberry	up/low

Scientific Name	Common Name	Upland/Lowland
Asimina triloba	Pawpaw	low
Carpinus caroliniana	Ironwood	up
Cercis canadensis	Eastern Redbud	up
Chionanthus virginicus	Fringetree	up/low
Cornus florida	White Dogwood	up
Crataegus crusgalli	Cockspur Hawthorn	up
Crataegus phaenopyrum	Washington Hawthorn	up
Halesia tetraptera	Silverbell	up/low
Hamamelis virginiana	Witchhazel	low
Ilex opaca	American Holly	up/low
Magnolia tripetala	Umbrella Magnolia	low
Ostrya virgniniana	Hophornbeam	up
Rhamnus caroliniana	Carolina Buckthorn	up/low
Viburnum prunifolium	Blackhaw	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
SHRUBS		
Amorpha fruticosa	Indigobush	low
Callicarpa americana	American Beautyberry	up/low
Calycanthus floridus	Sweetshrub	up/low
Ceanothus americanus	New Jersey Tea	up
Cephalanthus occidentalis	Buttonbush	low
Clethra alnifolia	Summersweet	low
Cornus amomum	Silky Dogwood	low
Corylus americana	American Hazelnut	up/low
Euonymus americanus	Hearts-a-bustin’	low
Hydrangea arborescens	Wild Hydrangea	up/low
Hydrangea quercifolia	Oakleaf Hydrangea	up/low
Hypericum frondosum	Golden St. John’s Wort	up/low
Hypericum prolificum	Shrubby St. John’s Wort	up
Ilex verticillata	Winterberry	low
Itea virginica	Virginia Sweetspire	low
Lindera benzoin	Spicebush	up/low
Photinia melanocarpa	Black Chokeberry	up/low
Photinia pyrifolia	Red Chokeberry	low
Physocarpus opulifolius	Common Ninebark	up
Sambucus canadensis	Elderberry	low
Symphoricarpos orbiculatus	Coralberry	up/low
Viburnum acerifolium	Maple leaf Viburnum	up

Scientific Name	Common Name	Upland/Lowland
Viburnum dentatum	Arrowwood Viburnum	up/low

Scientific Name	Common Name	Upland/Lowland
FORBS/GRASSES		
Antennaria plantaginifolia	Pussy Toes	up
Aquilegia canadensis	Wild Columbine	up/low
Asarum canadense	Wild Ginger	up
Carex cherokeensis	Cherokee Sedge	up/low
Carex pennsylvanica	Pennsylvania Sedge	up
Chasmanthium latifolium	River Oats	up/low
Eurybia divaricata	White Wood Aster	up
Heuchera americana	Alumroot	up/low
Hypericum hypericoides	St. Andrew's Cross	up
Iris cristata	Dwarf Crested Iris	up/low
Geranium maculatum	Wild Geranium	up
Mertensia virginica	Virginia Bluebells	low
Pachysandra procumbens	Allegheny Spurge	up
Phlox divaricata	Woodland Phlox	up/low
Polygonatum biflorum	Solomon's Seal	up/low
Polystichum acrostichoides	Christmas Fern	up/low
Smilacina racemosa	False Solomon's Seal	up/low
Symphyotrichum cordifolium	Blue Wood Aster	up
Spigelia marilandica	Indian Pink	low
Tradescantia virginica	Spiderwort	up/low

Exposed Aspect: Full sun, South and West facing slopes

Example: A steep slope in full sun currently managed as turf

Scientific Name	Common Name	Upland/Lowland
CANOPY TREES		
Acer rubrum	Red Maple	up/low
Carya glabra	Pignut Hickory	up
Carya ovata	Shagbark Hickory	up
Carya tomentosa	Mockernut Hickory	up
Celtis occidentalis	Hackberry	up/low
Diospyros virginiana	Persimmon	up

Scientific Name	Common Name	Upland/Lowland
Juniperus virginiana	Eastern Red Cedar	up
Liquidambar styraciflua	Sweetgum	up/low
Nyssa sylvatica	Blackgum	up/low
Pinus echinata	Shortleaf Pine	up
Pinus taeda	Loblolly Pine	up
Pinus virginiana	Virginia Pine	up
Prunus serotina	Wild Black Cherry	up/low
Quercus alba	White Oak	up
Quercus shumardii	Shumard Oak	up/low
Sassafras albidum	Sassafras	up
Ulmus alata	Winged Elm	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
SUB-CANOPY TREES		
Cercis canadensis	Eastern Redbud	up
Cornus florida	White Dogwood	up
Crataegus crusgalli	Cockspur Hawthorn	up
Crataegus phaenopyrum	Washington Hawthorn	up
Rhamnus caroliniana	Carolina Buckthorn	up/low
Rhus glabra	Smooth Sumac	up
Viburnum rufidulum	Rusty Blackhaw	up
Scientific Name	**Common Name**	**Upland/Lowland**
SHRUBS		
Callicarpa americana	American Beautyberry	up/low
Ceanothus americanus	New Jersey Tea	up
Hypericum prolificum	Shrubby St. John's Wort	up
Rhus aromatica	Fragrant Sumac	up
Rhus copallina	Shining/Winged Sumac	up
Robinia hispida	Prickly Locust	up
Rosa carolina	Carolina Rose	up
Symphoricarpos orbiculatus	Coralberry	up/low
Scientific Name	**Common Name**	**Upland/Lowland**
FORBS		
Amsonia tabernaemontana	Eastern Bluestar	up/low
Asclepias tuberosa	Butterfly Weed	up
Baptisia australis	Blue Wild Indigo	up/low
Coreopsis auriculata	Mouse-eared Coreopsis	up

Scientific Name	Common Name	Upland/Lowland
Coreopsis lanceolata	Lance-leaved Coreopsis	up
Echinacea pupurea	Purple Coneflower	up
Liatris aspera	Rough Blazing Star	up
Liatris spicata	Dense Blazing Star	up
Liatris squarrosa	Scaly Blazing Star	up
Monarda fistulosa	Wild Bergamot	up/low
Penstemon digitalis	White Beardstongue	up
Pteridium aquilinum	Bracken Fern	up/low
Opuntia humifusa	Prickly Pear	up
Phlox paniculata	Summer Phlox	up
Ratibida pinnata	Prairie Coneflower	up
Rudbeckia fulgida	Black-eyed Susan	up
Rudbeckia hirta	Black-eyed Susan	up
Schyzachyrium scoparium	Little Bluestem	up
Symphyotrichum novae-angliae	New England Aster	up/low
Symphyotrichum oblongifolium	Aromatic Aster	up/low

12.9 MASTER PLANT LIST

12.9.1 Approved List for ORNL Landscaping

This list is the approved ORNL landscaping plant list. It is a revision of the previous ORNL landscaping list and has recommendations from the campus landscaping plan update (Sustainable Sites Initiative 2020) by Environmental Landscape Design Associates incorporated.

Scientific Name	Common Name	Synonym
CANOPY		
Acer rubrum	Red Maple	
Acer saccharum	Sugar Maple	
Aesculus flava	Yellow Buckeye	
Betula nigra	River Birch	
Carya glabra	Pignut Hickory	
Carya ovata	Shagbark Hickory	
Carya tomentosa	Mockernut Hickory	
Celtis occidentalis	Hackberry	
Cladrastis lutea	American Yellowwood	
Diospyros virginiana	Persimmon	
Fagus grandifolia	American Beech	
Fraxinus pennsylvanica	Green Ash	
Ilex opaca	American Holly	
Juniperus virginiana	Eastern Red Cedar	
Liquidambar styraciflua	Sweetgum	
Liriodendron tulipifera	Tulip Poplar	
Morus rubra	Red Mulberry	
Nyssa sylvatica	Blackgum	
Pinus echinata	Shortleaf Pine	
Pinus strobus	White Pine	
Pinus taeda	Loblolly Pine	
Pinus virginiana	Virginia Pine	
Platanus occidentalis	Sycamore	
Prunus serotina	Wild Black Cherry	
Quercus alba	White Oak	
Quercus bicolor	Swamp White Oak	
Quercus coccinea	Scarlet Oak	
Quercus falcata	Southern Red Oak	
Quercus montana	Chestnut Oak	
Quercus palustris	Pin Oak	

Scientific Name	Common Name	Synonym
Quercus phellos	Willow Oak	
Quercus prinus	Chestnut Oak	
Quercus rubra	Red Oak	
Quercus shumardii	Shumard Oak	
Quercus stellata	Post Oak	
Quercus velutina	Black Oak	
Salix nigra	Black Willow	
Sassafras albidum	Sassafras	
Thuja occidentalis	Northern White Cedar	
Tilia americana	Basswood	
Tsuga canadensis	Eastern Hemlock	
Ulmus alata	Winged Elm	
Ulmus americana	American Elm	
SUB-CANOPY/ACCENT		
Aesculus pavia	Red Buckeye	
Alnus serrulata	Stream Alder	
Amelanchier arborea	Common Serviceberry	
Amelanchier laevis	Allegheny Serviceberry	
Aralia spinosa	Devil's Walking Stick	
Asimina triloba	Pawpaw	
Carpinus caroliniana	Ironwood	
Cercis canadensis	Eastern Redbud	
Chionanthus virginicus	Fringetree	
Cladrastis lutea	American Yellowwood	
Cornus florida	White Dogwood	
Crataegus phaenopyrum	Washington Hawthorn	
Crataegus calpodendron	Late Hawthorn	
Crataegus crus-galii	Cockspur Hawthorn	
Halesia tetraptera	Silverbell	
Hamamelis virginiana	Witchhazel	
Ilex opaca	American Holly	
Magnolia tripetala	Umbrella Magnolia	
Ostrya virginiana	Hophornbeam	
Oxydendrum arboreum	Sourwood	
Prunus americana	Wild Plum	
Ptelea trifoliata	Hoptree	
Rhamnus caroliniana	Carolina Buckthorn	
Rhus copallina	Shining/Winged Sumac	

Scientific Name	Common Name	Synonym
Rhus glabra	Smooth Sumac	
Viburnum prunifolium	Blackhaw	
Viburnum rufidulum	Rusty Blackhaw	
Scientific Name	**Common Name**	**Synonym**
SHRUBS		
Amorpha fruticosa	Indigobush	
Aronia arbutifolia	Red Chokeberry	*Photinia melanocarpa*
Arundinaria gigantea	River Cane	
Callicarpa americana	American Beautyberry	
Calycanthus floridus	Sweetshrub	
Ceanothus americanus	New Jersey Tea	
Cephalanthus occidentalis	Buttonbush	
Clethra alnifolia	Summersweet	
Cornus amomum	Silky Dogwood	
Corylus americana	American Hazelnut	
Euonymus americanus	Hearts-a-bustin'	
Fothergilla major	Fothergilla	
Hydrangea arborescens	Wild Hydrangea	
Hydrangea quercifolia	Oakleaf Hydrangea	
Hypericum frondosum	Golden St. John's Wort	
Hypericum hypericoides	St. Andrew's Cross	
Hypericum prolificum	Shrubby St. John's Wort	
Ilex verticillata	Winterberry	
Itea virginica	Virginia Sweetspire	
Kalmia latifolia	Mountain Laurel	
Lindera benzoin	Spicebush	
Photinia melanocarpa	Black Chokeberry	
Photinia pyrifolia	Red Chokeberry	*Aronia arbutifolia*
Physocarpus opulifolius	Common Ninebark	
Rhododendron maximum	Rosebay Rhododendron	
Rhododendron minus	Small-leaved Rhododendron	
Rhododendron periclymenoides	Pinxter-bush	
Rhus aromatica	Fragrant Sumac	
Rhus copallina	Shining/Winged Sumac	
Robinia hispida	Prickly Locust	
Rosa carolina	Carolina Rose	
Rosa palustris	Swamp Rose	
Sambucus canadensis	Elderberry	

Scientific Name	Common Name	Synonym
Symphoricarpos orbiculatus	Coralberry	
Vaccinium arboreum	Farkleberry	
Viburnum acerifolium	Maple leaf Viburnum	
Viburnum dentatum	Arrowwood Viburnum	
Scientific Name	**Common Name**	**Synonym**
FORBS		
Amsonia tabernaemontana	Eastern Bluestar	
Antennaria plantaginifolia	Pussy Toes	
Aquilegia canadensis	Wild Columbine	
Ariasema triphyllum	Jack-in-the-pulpit	
Aruncus dioicus	Goat's Beard	
Asarum canadense	Wild Ginger	
Asclepias incarnata	Swamp Milkweed	
Asclepias syriaca	Common Milkweed	
Asclepias tuberosa	Butterfly Weed	
Aster cordifolius	Blue Wood Aster	*Symphyotrichum cordifolium*
Aster divaricatus	White Wood Aster	*Eurybia divaricata*
Aster laevis	Smooth Aster	*Symphyotrichum laeve*
Aster novae-angliae	New England Aster	*Symphyotrichum novae-angliae*
Aster oblongifolis	Aromatic Aster	*Symphyotrichum oblongifolium*
Aster patens	Late Purple Aster	*Symphyotrichum patens*
Aster undulatus	Waxy Leaf Aster	*Symphyotrichum undulatum*
Astilbe biternata	False Goat's Beard	
Baptisia australis	Blue Wild Indigo	
Conoclinium coelestinum	Wild Ageratum	*Eupatorium coelestinum*
Coreopsis auriculata	Mouse-eared Coreopsis	
Coreopsis lanceolata	Lance-leaved Coreopsis	
Echinacea purpurea	Purple Coneflower	
Eupatorium coelestinum	Wild Ageratum	*Conoclinium coelestinum*
Eupatorium fistulosum	Joe-pye Weed	
Eupatorium purpureum	Woodland Joe-Pye Weed	
Eurybia divaricata	White Wood Aster	*Aster divaricatus*
Gaultheria procumbens	Wintergreen	
Geranium maculatum	Wild Geranium	
Helianthus angustifolius	Swamp Sunflower	
Helianthus occidentalis	Western Sunflower	
Heuchera americana	Alumroot	
Hymenocallis caroliniana	Spiderlily	*Hymenocallis occidentalis*

Scientific Name	Common Name	Synonym
Hymenocallis occidentalis	Spiderlily	*Hymenocallis caroliniana*
Impatiens capensis	Jewel Weed	
Iris cristata	Dwarf Crested Iris	
Liatris aspera	Rough Blazing Star	
Liatris cylindracea	Ontario Blazing Star	
Liatris spicata	Dense Blazing Star	
Liatris squarrosa	Scaly Blazing Star	
Lobelia cardinalis	Cardinal Flower	
Lobelia syphilitica	Big Blue Lobelia	
Mertensia virginica	Virginia Bluebells	
Monarda didyma	Beebalm	
Monarda fistulosa	Wild Bergamot	
Opuntia humifusa	Prickly Pear	
Pachysandra procumbens	Allegheny Spurge	
Penstemon canescens	Hairy-Beardtongue	
Penstemon digitalis	White Beardtongue	
Penstemon laevigatus	Smooth Beardtongue	
Phlox divaricata	Woodland Phlox	
Phlox glaberrima	Smooth Phlox	
Phlox paniculata	Summer Phlox	
Phlox stolonifera	Crawling Phlox	
Physostegia virginiana	False Dragonhead/Obedient Plant	
Polygonatum biflorum	Solomon's Seal	
Pycnanthemum torrei	Torry's Mountain Mint	
Ratibida pinnata	Prairie Coneflower	
Rudbeckia fulgida	Orange Coneflower	
Rudbeckia hirta	Black-eyed Susan	
Rudbeckia triloba	Brown-eyed Susan	
Sedum ternatum	Wild Stonecrop	
Silene virginica	Fire Pink	
Silphium terebinthenaceum	Prairie Dock	
Sisyrinchium angustifolium	Blue-eyed Grass	
Smilacina racemosa	False Solomon's Seal	
Solidago caesia	Blue-Stemmed Goldenrod	
Solidago canadensis	Canada Goldenrod	
Solidago flexicaulis	Zig-Zag Goldenrod	
Solidago nemoralis	Southern Gray Goldenrod	
Solidago odora	Fragrant Goldenrod	
Solidago ptarmicoides	Prairie Goldenrod	

Scientific Name	Common Name	Synonym
Solidago rugosa	Stiff Goldenrod	
Solidago speciosa	Showy Goldenrod	
Solidago sphacelata	Short-Pappus Goldenrod	
Solidago ulmifolia	Elm-Leaved Goldenrod	
Spigelia marilandica	Indian Pink	
Symphiotrichum oblongifolium	Aromatic Aster	*Aster oblongifolis*
Symphyotrichum cordifolium	Blue Wood Aster	*Aster cordifolius*
Symphyotrichum novae-angliae	New England Aster	*Aster novae-angliae*
Symphyotrichum laeve	Smooth Aster	*Aster laevis*
Symphyotrichum patens	Late Purple Aster	*Aster patens*
Symphyotrichum undulatum	Waxy Leaf Aster	*Aster undulatus*
Tradescantia virginica	Spiderwort	
Vernonia gigantea	Ironweed	
Veronicastrum virginicum	Culver's Root	

Scientific Name	Common Name	Synonym
GRASSES/SEDGES		
Andropogon gerardii	Big Bluestem	
Andropogon glomeratus	Wooly/Bushy Broomsedge	
Andropogon ternarius	Splitbeard Bluestem	
Andropogon virginicus	Broomsedge	
Arundinaria gigantea	River Cane	
Bouteloua cutipendula	Side-oats Grama	
Carex cherokeensis	Cherokee Sedge	
Carex lurida	Lurid Sedge	
Carex pennsylvanica	Pennsylvania Sedge	
Carex vulpinoidea	Fox Sedge	
Chasmanthium latifolium	River Oats	
Eleocaharis quadrangulata	Square-sided spikerush	
Elymus virginicus	Virginia Wild Rye	
Eragrostis spectabilis	Purple Lovegrass	
Hystrix patula	Bottlebrush Grass	
Juncus effusus	Soft Rush	
Panicum virgatum	Switchgrass	
Saccharum giganteum	Sugarcane Plumegrass	
Schoenoplectus pungens	Three-square rush	*Scirpus americanus*
Schoenoplectus tabernaemontani	Soft-stem Bulrush	*Scirpus validus*
Schyzachyrium scoparium	Little Bluestem	
Scirpus americanus	Three-square rush	*Schoenoplectus pungens*

Scientific Name	Common Name	Synonym
Scirpus cyperinus	Woolgrass	
Scirpus validus	Soft-stem Bulrush	*Schoenoplectus tabernaemontani*
Sorghastrum nutans	Indian Grass	

Scientific Name	Common Name	Synonym
FERNS		
Adiantum pedatum	Maidenhair Fern	
Asplenium platyneuron	Ebony Spleenwort	
Athyrium filix-femina	Lady Fern	
Deparia acrostichoides	Silvery Glade Fern	
Dryopteris intermedia	Fancy Wood Fern	
Dryopteris marginalis	Marginal Wood Fern	
Osmunda cinnamomea	Cinnamon Fern	
Osmunda regalis	Royal Fern	
Polystichum acrostichoides	Christmas Fern	
Pteridium aquilinum	Bracken Fern	

Scientific Name	Common Name	Synonym
AQUATICS		
Alisma subcordata	Water Plantain	
Eleocaharis spp.	Spikerush	
Equisetum arvense	Field Horsetail	
Equisetum hymale	Scouring Rush	
Hibiscus laevis	Halberd-leaved Mallow	
Hibiscus moscheutos	Swamp Rose Mallow	
Juncus effusus	Soft Rush	
Nelumbo lutea	American lotus	
Nuphar lutea	Spadderdock	
Nymphaea odorata	American White Water Lily	
Pontederia cordata	Pickerelweed	
Sagittaria latifolia	Arrowhead	
Saururus cernuus	Lizard's Tail	
Scirpus cyperinus	Woolgrass	
Typha latifolia	Broad-leaf Cattail	
Vallisneria americana	Water Celery	

Scientific Name	Common Name	Synonym
VINES		
Bigonia capreolata	Crossvine	

Scientific Name	Common Name	Synonym
Campsis radicans	Trumpet Creeper	
Clematis viorna	Leatherflower	
Clematis virginiana	Virgins Bower	
Lonicera sempervirens	Coral Honeysuckle	
Parthenocissus quinquefolia	Virginia Creeper	
Passiflora incarnata	Passionflower	
Rosa setigera	Climbing Prairie Rose	
Wisteria frutescens	American Wisteria	
Limited Use Plants – Require approval. Not on ORR, but may meet special needs		
CANOPY		
Acer freemanii	Freeman Maple	
Magnolia virginiana	Sweetbay Magnolia	
SHRUBS		
Fothergilla gardenii	Dwarf Fothergilla	
Ilex glabra	Inkberry	
Yucca filamentosa	Yucca	
FORBS		
Echinacea tennesseensis	Tennessee Coneflower	
GRASSES/SEDGES		
Muhlenbergia capillaris	Pink Muhly Grass	
Sporobolus heterolepis	Prairie Dropseed	

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