LATIS 2008

Landscape Architecture Technical Information Series Number 2

Successful Ecological Restoration:

A Framework for Planning/Design Professionals

Lee R. Skabelund, ASLA; G.M. Kondolf; Craig Johnson, ASLA; and Allegra Bukojemsky, ASLA

AMERICAN SOCIETY OF LANDSCAPE ARCHITECTS

ASLA FUND

LATIS

Successful Ecological Restoration: A Framework for Planning/ Design Professionals

by Lee R. Skabelund, ASLA; G.M. Kondolf; Craig Johnson, ASLA; and Allegra Bukojemsky, ASLA

636 Eye Street, NW
Washington, DC 20001-3736
202 898 2444
www.asla.org

Library of Congress Catalog Card
Number 84-07-1877
ISSN:0195-5764

LATIS is produced by ASLA as an education service to the profession of landscape architecture.

Policy and subject matter selection is administered through ASLA's Professional Practice Library under the guidance of the Professional Practice Institute, the Council on Education, and the Council of Professional Practice Networks.

Cover photos:

Center photo: Konza Prairie, courtesty Lee R. Skabelund.

Konza Prairie Biological Station is a 3,487 hectare native tallgrass prairie preserve owned by The Nature Conservancy and Kansas State University and operated as a field research station by the K-State Division of Biology. For more information, visit *www.konza.ksu.edu*.

Top left photo: Yellowstone - Lewis River, courtesy Lee R. Skabelund

About the Authors

Lee R. Skabelund, ASLA, is an Assistant Professor in Landscape Architecture / Regional and Community Planning at Kansas State University. Lee serves on KSU's Stewardship (Sustainability) Subcommittee, is Chair of the Responsible Stewardship Building Committee for KSU's College of Architecture, Planning and Design, and continues to help restore landscape functions whenever he can. He is a member of the Society for Ecological Restoration, and served as co-chair of ASLA's Reclamation & Restoration Professional Practice Network from 2002-2008. He received an MLA from the School of Natural Resources at the University of Michigan and a BLA at Utah State University.

Dr. G. Mathias (Matt) Kondolf, Professor of Environmental Planning and Geography at the University of California, Berkeley is a fluvial geomorphologist specializing in environmental river management, impacts of human development on runoff and sediment yield, and restoration of rivers and streams. Matt has taught many landscape architecture students at UC Berkeley. He received a PhD in Geography and Environmental Engineering at The Johns Hopkins University, an MS of Earth Sciences at University of California, Santa Cruz, and an AB Cum Laude in Geology from Princeton University.

Craig W. Johnson, ASLA, taught and guided numerous students as a professor of Landscape Architecture and Environmental Planning at Utah State University between 1966 and 2008. Craig is a licensed Landscape Architect in Minnesota and Utah, and he has worked extensively on ecological restoration and land and water conservation projects. He received a BLA from Michigan State University, an MLA from the University of Illinois, and an MS degree in Fisheries and Wildlife Biology from South Dakota State University.

Allegra Bukojemsky, ASLA, leads Biohabitats' San Francisco Bay Bioregion office and has worked on many habitat restoration projects. She is a founding member and current co-chair of the ASLA Sustainable Design and Development Professional Practice Network. Allegra holds a Masters of Landscape Architecture from the University of California, Berkeley and a Bachelor of Science in Zoology with a minor in Industrial Design from San Jose State University.

Publisher's Note

The American Society of Landscape Architects publishes the Landscape Architecture Technical Information Series (LATIS) to encourage professionals to share specialized expertise relating to landscape architecture. ASLA considers LATIS papers to be important contributions to a necessary and ongoing dialogue within a large and diverse community of landscape architecture researchers and practitioners. ASLA oversees a rigorous peer review process for all LATIS papers to ensure accuracy of content. Each author offers a unique perspective on the practice area covered, reflecting his or her portfolio of professional experiences.

This LATIS defines and provides a history of ecological restoration and designs, identifies restorable habitats and ecosystems and the steps in a restoration design process, describes restoration successes, addresses how landscape architects contribute to ecological restoration efforts, provides project examples, and lists key issues and how to address them.

Feedback on this LATIS and on the series in general should be sent to ASLA, c/o Professional Practice Manager, 636 Eye Street NW, Washington DC 20001. ASLA welcomes suggestions for future LATIS topics that will broaden awareness of new and/or rapidly evolving practice areas within landscape architecture and enhance technical proficiency for practicing in these areas.

Table of Contents

List of Photos

List of Figures

Preface

If you wish to make a difference in the world, try ecological restoration. Seek to heal the earth, its cities, ecosystems, and human communities—and in the process bring meaning to everyone involved.

Like the best work of landscape architecture, the art and science of ecological restoration require awareness, persistence, and patience. The fruit of our collective restoration efforts can be transformed landscapes, communities, and people.

Ecological restoration seeks to reconnect people and wildlife to landscapes previously damaged by a range of human and natural disturbances while sustaining the ecosystem services we depend upon for our well-being. Reasons for restoring ecological systems include the need to meet regulations and habitat mitigation requirements, to enhance our local communities (ecologically, socially, and economically), and to improve air, soil, and water quality.

Because of the tremendous need to heal and renew damaged landscapes, we believe that ecological restoration will continue to play a pivotal role in our collective efforts to restore large-scale ecosystems while also restoring clean water, clean air, fertile soils, and other essential ecosystem services.

In our view, the thoughtful integration of art and science is what unites landscape architecture and ecological restoration. By helping mend damaged and degraded lands, ecological restoration transforms people and landscapes. It can be seen as reflecting the maturation of the environmental movement, from early "doom and gloom" (when many pressing problems were first recognized and documented) to a positive, proactive healing of ecological systems.

This LATIS paper explores how planners and designers can successfully incorporate ecological restoration principles into their project work, and how they can help restoration[1] practitioners meet their goals to restore ecosystem functions in diverse landscape contexts. Landscape architects are frequently well-positioned to lead or otherwise participate in ecological restoration projects by virtue of their experience in design, construction administration, public process, and coordinating multidisciplinary teams.

This paper draws on the ecological restoration literature and in-depth interviews with more than 15 highly regarded practitioners in the field. We appreciate the time and ideas shared by each of these professionals, and the helpful comments provided by the paper's peer reviewers and ASLA staff.

If you have thoughts or comments about this paper, please contact Lee R. Skabelund at lskab@ksu.edu.

1 "Restoration" when used alone in this document means "ecological restoration."

I. What is Ecological Restoration?

Definitions

Before determining what we will restore, we should consider how "restoration" and other closely related terms have been used by those proposing, implementing, and evaluating ecological restoration efforts.

At the outset, we should recognize that the term "ecology" means the study of interrelationships between organisms, elements, and systems; it does not mean "landscape," "nature," or "natural." Thus, "restoration ecology" is the study of restored ecosystems, while "ecological restoration" is the practice of restoring natural ecosystems that have been lost, degraded, or otherwise disrupted.

The following definition is endorsed by the Society for Ecological Restoration International (SER 2004): "Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed." This definition offers a succinct and overarching statement of intent, while allowing for greater specificity at the individual project level. Elaborating further, SER describes ecological restoration as "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability." Sometimes the process of ecological restoration attempts "to return an ecosystem to its historic trajectory" (2004, Section 1). Necessarily, a restoration project must fit with both its present and future context.

In our view, the **primary goal** of most ecological restoration projects should be to r**e-establish functional ecosystems** of designated types in a manner that allows for the maturation of these systems by natural processes—after exotic weed control, planting, and possibly grading, temporary hydrologic and biotechnical stabilization, soil improvements, and/or irrigation. **Restored ecosystems should be capable of responding to changing environmental conditions,** particularly if they are within or near urban landscapes. Consideration of climate change impacts will need to be addressed. In many cases, once a site or ecosystem is restored, it will likely require periodic management in order to maintain ecosystem integrity in response to ongoing human impacts and natural disturbances. Thus, although self-sustaining restoration may be our aspiration, managed restoration is typically a more realistic goal.

Terms used in association with ecological restoration include: rehabilitation, reclamation, repair, remediation, re-vegetation, re-creation, creation, enhancement, management, and mitigation.[1]

---

1 To read more about restoration terms, definitions, and goals refer to Cairns 1993; MacMahon & Jordan 1994; Bradshaw 1997; Ehrenfield 2000; Higgs 2003; Mitsch & Jørgensen 2004; SER 2004; and Cairns 2006.

Because the term "restoration" is used in so many different ways, it is helpful to specifically define what we mean when we use the term "ecological restoration" and other related terms. In short, we should clearly and realistically state what we are aiming to do. Additionally, we ought to state our goals in a manner that can be evaluated (ideally by ecologists and other scientists), especially in terms of expected changes in patterns, processes, and dynamics.

During the process we should ask: What do we specifically mean when we use certain terms to describe our project intentions? Is our goal "natural authenticity" (Clewell 2000)? Are we aiming for "ecological integrity," "historical fidelity," social engagement through the process of "assisted recovery," and/or "wild design" (Higgs 2003, 95–96)? Or, are we aiming for all four of these?

Being as clear and as explicit as we can about our terms, intentions, and plans enables restoration project teams and interested observers to better understand and evaluate both the process and the results of the restoration activities we undertake. When we are explicit about our goals, objectives, and expected levels of performance, we can better learn from our successes and our mistakes—as well as the unexpected surprises that dynamic, living systems bring. We also will have a better yardstick to measure or assess what we have done.

Key issues to be considered during ecological restoration and restoration design

Ecological restoration is a very complex field that strives to re-create or reorganize natural systems and flows via restoration planning and implementation. It is not just about what a stream or forest or prairie should look like, but about how these systems should function.

As a result, a complex study and understanding of an ecosystem are needed to correctly design and balance water flows, temperatures, soil structure, vegetation species and structure, and wildlife habitat needs, among many other variables.

Because of the technical aspects of ecological restoration, this field tends to be dominated by scientists who understand ecosystem needs and functions and who can model and predict the needs and flows within these complex systems. This is not to say that landscape architects do not have or cannot gain some of this knowledge (they do, or can), nevertheless landscape architects are usually only one of many disciplines on a restoration team.

Because landscape architects understand spatial relationships and the layering of site and landscape information, they are often well poised to work in ecological restoration by helping facilitate the many needs and aspects of a restoration project, especially those involving public access or influence.

A number of crucial issues must be considered by members of an ecological restoration team:

Invasive species—what invasive species are present or may pose a problem in the future, and what invasive species controls are best?

Habitat—interior versus edge, buffer requirements, food, water, and shelter needs, etc.

Soils—are the soils appropriate for intended vegetation and hydrology; if not, what should be done?

Contamination—what types of contamination exist; how can pollutants be best addressed?

Future surrounding uses—how will surrounding uses influence what can or should be done?

Climate change—how will changes in climate (abrupt or gradual) influence our restoration efforts?

Succession—how will changes in vegetation (over time) influence our proposed restoration plans?

Public opinion—how will residents and other stakeholders be involved and perceive our work?

Funding for restoration and long-term monitoring/management—what funds can be secured for implementation as well as for ongoing monitoring and adaptive management activities?

Two examples highlight what we will need to consider during the planning/design process:

A. Because many species and habitats are in peril, we need to consider how specific restoration projects will protect at-risk habitats and sensitive, rare, threatened, and endangered species (especially in or near urban areas, where invasive species, degraded soils and water, and inputs of pollutants and other contaminants are of particular concern).

B. Given that underlying hydro-geomorphic processes, soils, and other landscape functions are often degraded, we need to consider how we will restore well-functioning processes within a context that will certainly include human and natural disturbances and other ongoing changes. We also need to determine the most appropriate ways to monitor and learn from the systems we restore.

During the process of restoration design, we will typically need to

- Offset construction impacts to ecosystems and human communities;
- Improve and create functional and diverse ecosystems and habitats;
- Sustain natural capital and ecosystem services in well-functioning ecological systems; and
- Engage local residents in place-making, place-keeping, and lifelong learning and enjoyment.

As seen from this short list of issues and considerations, there are elements necessary for a restoration design project to be successful in a technical and ecological sense and elements necessary for a restoration design project to be successful from sociocultural and political perspectives. Integrating our responses to the needs and demands associated with these realms should lead to sustainable or regenerative solutions.

From the foregoing discussion it should be clear that if we are to help restore functional ecological systems we must

- Understand biophysical structure, ecological processes, and contextual issues;
- Assess human impacts and influences;
- Determine what to restore and what to accept as constraints;
- Set appropriate goals and monitoring actions based on ecological and social factors; and
- Design suitable monitoring protocols to evaluate project success and guide management.

Photos 1 & 2. Located in north-central Kansas, many ecosystems within the Konza Prairie have the potential to serve as references for ecological restoration efforts in the Flint Hills Eco-Region. Reference sites are extremely valuable in our efforts to successfully restore viable ecosystems.
Photos courtesty Lee R. Skabelund

II. A Brief History of Ecological Restoration and Restoration Design

The field of ecological restoration has many roots, including the pioneering "Emerald Necklace," created by Frederick Law Olmstead at the Boston Fens, and Jen's Jensen's Lincoln Memorial Park.

Among the important intellectual inspirations for the field was Aldo Leopold's work in reassembling prairie ecosystems in Wisconsin and his book, *A Sand County Almanac*, which has been a touchstone for many practitioners. Influential scholars include William R. Jordan III, who in 1981 helped initiate the journal *Restoration & Management Notes* (now *Ecological Restoration*) and co-edited *Restoration Ecology: A Synthetic Approach to Ecological Research*, where restoration was described by the authors as a true "test for ecology" (Bradshaw 1987).

Early practitioners in the field included Ed Garbisch (who restored non-tidal and tidal wetlands along the east coast of the United States), Darrell Morrison (designer of the Lady Bird Johnson Wildflower Center gardens), and the firm Andropogon Associates (which helped restore woodlands and other ecosystems at Central Park and in other significant parklands).

In 1977, the U.S. Congress established the Abandoned Mine Land (AML) Program, allocating billions of dollars generated by coal production to reclaim strip mines into useful productive lands. As part of Title IV of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), the AML Program seeks to reclaim land and water resources adversely affected by coal mining. Although not considered ecological restoration, the field of land reclamation helped practitioners and scientists develop many of the planning, design, implementation, and project evaluation techniques employed by restoration practitioners and researchers today (Cairns 1995).

In response to growing interest in ecological restoration the Society for Ecological Restoration (SER) was founded in 1987. SER is a non-profit organization that connects individuals and organizations who engage in ecologically sensitive repair and management of ecosystems as they share experience, knowledge, and diverse cultural perspectives. SER members are recognized by public and private enterprises as an important source for expertise on restoration science, practice, and policy throughout the world *(www.ser.org/content/15_years_leadership.asp)*.

By 1990, many agencies and organizations began to mandate the restoration of disturbed sites. However, agency staff, non-profit groups, and consultants used the term "restoration" to describe widely divergent activities such as: re-vegetation using non-native species, canal dredging, single species mitigation, and occasionally the attempt to rebuild native ecosystems. These "restoration projects" often had narrow, short-term goals that made restoration success questionable. As an organization with growing influence, SER helped clarify terminology and described the intentions, actions, and criteria for ecological restoration, thus establishing itself as an important forum where restoration tools and concepts could continue to be refined and expanded upon as the field matured.

In 1993 the scientific journal *Restoration Ecology* was first published, and the journal has played a significant role in deepening the study of ecological restoration projects, including the successes and failures of implemented projects.

The Global Restoration Network (GRN), launched by SER in 2007, offers the field of ecological restoration a searchable database and web-based portal to many aspects of the field—from historic ecosystems and recent causes of degradation to in-depth case studies and proven restoration techniques relevant to project work worldwide (*www.globalrestorationnetwork.org/*).

ASLA's Reclamation and Restoration Professional Practice Network serves the society as a primary vehicle for sharing ideas about ecological restoration among ASLA members. This paper is part of a multi-year research effort intended to encourage critical thinking about the roles of landscape architects and other planners/designers in ecological restoration project work.

III. What to Restore

In the United States, landscape architects and other restoration professionals attempt to restore many different types of habitats and ecosystems. Restoration of these areas may be driven by a variety of factors, including regulations such as the Clean Water Act, endangered species mitigation, hazard reduction (flooding), and community enhancement. Examples of impacts and opportunities associated with commonly restored habitats and ecosystems are briefly noted below. Invasive species, pollution, and poorly conceived urban development represent significant challenges for each of these ecosystems. [2]

Prairies, Meadows, and Other Upland Grassland Habitats—Few areas of upland grasslands exist in a native condition. Many grasslands have been disturbed by agricultural practices or have been overtaken by woody plants and invasive species. These ecosystems are usually dependant on disturbance regimes such as wildfire or grazing, and have very diverse relationships with many animal and insect species. Restoration potential of prairies, meadows, and grasslands is high.

Savannas, Woodlands, and Forests—"Savanna" is a term that may mean an open, grassy plain in some parts of the world, but in the U.S. it has a narrower meaning. Here savannas are typically seen as transitional ecosystems—sharing properties of woodlands and grasslands. Fire and grazing are important to the long term survival and health of savannas. Woodlands are typically small portions of remnant forests and are typical in urban and suburban landscapes as well as areas dominated by farmland. Often disturbed by road building, unsustainable logging practices, and recreation, many forests now lack the diverse canopy structure of a stable, intact forest ecosystem. Many forest types are dependent on low-impact grazing and low-intensity fires. Decaying material from downed woody debris is generally indispensible to forested landscapes if they are to sustain their full habitat potential. Forestland restoration generally takes decades; restoration of savannas and woodlands may occur over shorter timeframes.

Rivers and Streams—Impacted by overgrazing, damming, urban stormwater inputs, and other impacts, many rivers and streams in the U.S. are rapidly down-cutting and eroding, loosing connection to their natural floodplain, have poor water quality, and are unable to sustain natural habitat. Urban development has increased stormwater runoff, increasing flood hazards downstream, and degraded habitat and aquatic ecosystems. Stream restoration requires detailed knowledge of upstream conditions and technical expertise in geomorphology and river hydrology.

---

2 *See* Appendix A: Learning from Ecological Restoration Projects in North America for web links and other references to restoration programs and projects related to the ecosystem types discussed above.

Freshwater Marshes and Wetlands—Often filled or drained for urban development or agriculture, and impacted by nutrient-rich, toxic, and high-volume stormwater runoff, there is a common understanding of the importance of wetlands in flood reduction, aquifer recharge (where the geology supports recharge), biological diversity, and as carbon sinks. Restoration potential is high, but restored ecosystems are generally much simpler in structure and function than reference ecosystems (i.e., ecosystems that serve as models for those being restored and can later serve in the evaluation of restored ecosystems).

Coastlines and Saltwater/Tidal Marshes—Crucial for shoreline stabilization and ocean health, many coastal wetlands, dune systems, and shorelines have been lost and may not provide sufficient habitat for the many endangered species dependant on these habitats. Restoration is possible, although restored coastal areas are susceptible to abrupt and long-term climate-related changes.

Seasonal Wetlands and other Transitional Ecosystems—Frequently overlooked in the past, seasonal wetlands such as vernal pools are increasingly rare and threatened, along with the many species of arthropods, amphibians, and birds that depend on these ecosystems for habitat. Restoration is possible but requires in-depth scientific understanding of these and adjacent systems.

Desert or Arid Landscapes and High-Elevation Habitats—These systems typically have fragile soils and extreme climatic conditions, making impacts to these ecosystems particularly stressful and sometimes quite difficult to repair. Restoration is possible but typically requires an extended period of time to re-establish soils and vegetation.

IV. Steps in Restoration Design

The following steps are necessary parts of an ecological restoration or restoration design process. More detailed guidelines for developing and managing ecological restoration projects are presented in *Ecological Restoration: Principles, Values, and Structure of an Emerging Field* (Clewell and Aronson 2007), and these guidelines are summarized in Appendix B of this LATIS paper.

A. Establish a collaborative team that can effectively address the specific ecological restoration requirements of the project. To be most effective, collaboration between landscape architects and other necessary disciplines must begin as preliminary goals and objectives are suggested in the Request for Qualifications and when responding to a Request for Proposals.

B. Undertake a site inventory (ideally with pre-monitoring of vegetation, soils, hydrology and/or other critical components) and ***evaluate the historical context***.

C. Understand the social, cultural, and political context—with a close look at surrounding land uses, local and regional zoning laws and other regulations, funding and land management mechanisms, and expected long-term land uses in the area.

D. Review historical information and reference sites to develop realistic models of what could be restored given past, present, and future conditions on the site and in the region, thus developing a "guiding image" for the restoration (Kondolf and Larson 1995).

E. Strategically address technical, ecological, sociocultural, political, and economic constraints and opportunities and do so in an integrated fashion.

F. Set goals and articulate specific objectives related to hydro-geomorphology, soil composition, landform, streambank/shoreline structure, water quality, species targets, and biological diversity, depending on the particular needs of the site, its context, and the proposed ecosystem type(s).

G. Develop detailed designs and construction drawings and specifications, supported by graphic and written information to effectively portray expected costs, processes, and results (e.g., ecological structure, function and dynamics, needed physical infrastructure, programming needs/requirements, monitoring and maintenance needs/requirements/criteria, etc.).

H. Construct or otherwise implement the proposed project, implementing the restoration design in accord with project goals and objectives, and documenting any changes to the final construction plans (including drawings or specifications).

I. Monitor the restored ecosystem so that management of the system can be adapted, and so that similar projects can be improved in the future (recognizing that each restoration project is an experiment to be learned from).

V. Defining "Restoration Success"

To achieve our ecological restoration goals and objectives, planners and designers must work closely with those with the necessary expertise in soils, hydrology, biology, botany/plant science, wildlife ecology, history, sociology, political science, engineering, and other pertinent disciplines—depending on where, how large, and how complex the issues related to our project are.

A few examples regarding the potential complexity and challenges associated with ecological restoration in urban areas are highlighted in the following paragraph.

In urbanizing contexts, human influences make "full restoration" (the complete recovery of ecosystems) very difficult. Significant challenges include the spread of invasive plant and animal species and the addition of atmospheric and waterborne nutrients and pollutants. Subtle and frequently unrecognized challenges include gradual ecosystem and landscape changes that occur in response to modifications in climatic conditions, soil structure and composition, water manipulations at the watershed and sub-basin levels, and the loss of native flora and fauna. To address these complexities, we need the perspectives available from other disciplines and from well-informed clients and local residents.

The Role of Multidisciplinary Teams in Achieving Ecological Restoration Success

Although planners and designers need not be involved in every ecological restoration effort, where restoration projects meet cities, suburbs, small towns, and rural communities, it is our sense that planners/designers can and should play very important roles—particularly when they have experience working with stakeholders and/or are familiar with ecological design.

Garnering the support of "local stakeholders," (a title that includes all community members who participate or speak their mind), is generally indispensable to sustaining restored ecosystems over the long term. Achieving "stakeholder success" requires project teams to address perceptions and aesthetics, economic benefits, recreation, and education, and it is one of three important aspects of successful ecological restoration efforts (see Figure 1).

The most effective restoration projects lie at the intersection of the three primary axes of success: Ecological Success, Stakeholder Success, and Learning Success.

Ecological success underpins the overall success of a restoration project, as there can be no ecological restoration without success in this arena.

Stakeholder success reflects human satisfaction with and commitment to the restoration outcomes.

Learning success reflects advances in scientific knowledge and management practices that will benefit future restoration, management, and conservation actions.

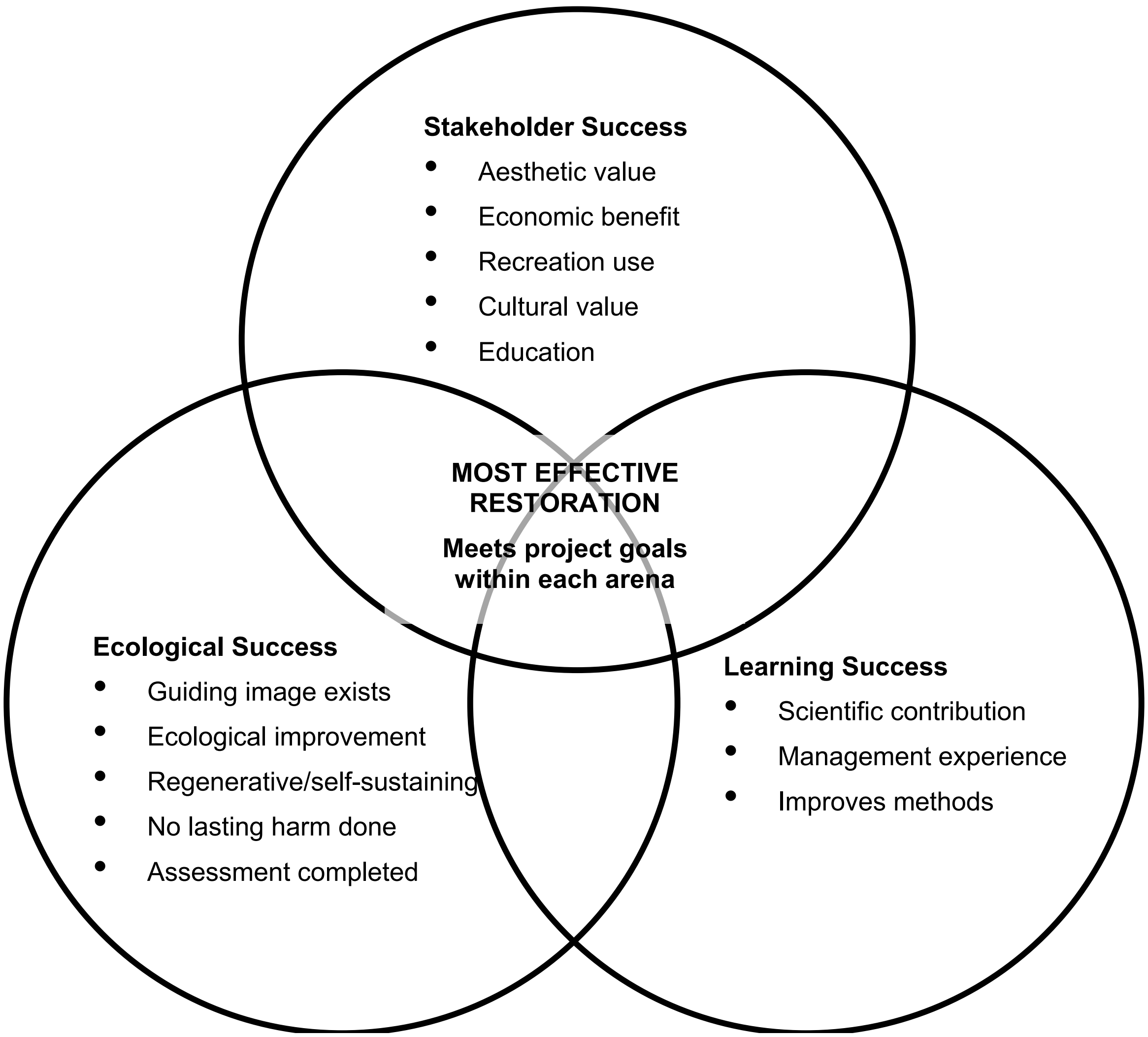

Figure 1 - Most Effective Restoration Projects (adapted from Palmer, et al. 2005)

The most effective restoration projects are successful in addressing ecological structure and function (ecological success), human needs and interests (stakeholder success), and learning needs and opportunities (learning success). (Figure and text adapted from Palmer et al. 2005; used with permission from lead author Margaret Palmer.)

Principles for Successful Ecological Restoration Design Efforts[3]:

A fact that team members must remember is that ecological restoration remains a good part "art" and "politics"—with the critical need to employ available knowledge of ecological processes, technical know-how, and social interests (adapted from van Diggelen et al. 2001).

The following principles provide guidance for ecological restoration work being contemplated by landscape architects. These six principles are deepened by Clewell and Aronson (2007), when they discuss "holistic ecological restoration" in their book *Ecological Restoration*, and through their detailed discussion of "Guidelines for Developing and Managing Ecological Restoration Projects" (refer to Appendix B for a summary of SER's 51 guidelines).

1. Use an ecosystem-based approach to ecological restoration design by accounting for landscape and ecosystem structure and function over multiple scales and understanding site and landscape changes over time.

2. Involve local community members in ecological restoration planning and decision making, and develop appropriate vehicles for public education and outreach.

3. Make "place-making" part of an integrated approach to ecological restoration, accounting for biotic and abiotic elements particular to specific places, to aesthetics, and to the sense of local community—ecological and cultural.

4. Do as little as is necessary to restore target ecosystems, critical landscape components, and life-sustaining functions in order to conserve resources and time.

5. Develop monitoring and management protocols as part of planning documents in order to effectively address internal and external influences that might undermine the success of an ecological restoration project.

6. Learn from other ecological restoration projects and work closely with scientists and other professionals to prepare and implement project plans/designs and to understand both successes and failures related to our project efforts.

Because of the complex nature of dynamic ecosystem processes, the outcomes of ecological restoration efforts are more open-ended than other design work. As a

---

3 These principles are adapted from a paper prepared for ASLA's 2002 Annual Meeting in San Jose, California, by Bernie Dahl, Fred Phillips, and Lee Skabelund (*see* pages 137–141 of the 2002 "Annual Meeting Proceedings"). Refer also to Davy and Perrow (2002)—*Handbook of Ecological Restoration: Volume 1, Principles of Restoration*.

result, landscape architects and other designers need to think of proposing restoration strategies as opposed to static or fixed restoration designs. We must also budget time to monitor and evaluate restoration projects and then disseminate written accounts of these post-construction efforts—with objective discussions of lessons learned—for this field to advance.

SER's Global Restoration Network and National River Restoration Science Synthesis (NRRSS) are examples of online restoration databases that can help us critically reflect on and improve our ecological restoration efforts. The National Research Council (1992; 2002) and numerous journal articles offer very helpful insights into issues related to ecological restoration.

Technical and Ecological Elements: Examining the Essentials of Restoration Design

Ecological restoration requires knowledge of large-scale landscape processes, site-scale ecology, human interests, sociopolitical factors, integrative planning, design, monitoring and assessment, and adaptive management. Strategies for "assisted recovery," such as employing invasive plant controls, must be considered as part of larger ecological restoration and landscape planning and land-use management efforts. Restoration in urbanizing contexts must be qualified by the specific limitations that urban conditions present. Selecting "the best ecological restoration alternative" must be based on the limits imposed by biophysical, sociopolitical, and economic constraints *and* by realistic goals and project evaluation criteria.

Where do we learn about limitations, and how do we develop realistic goals and project evaluation criteria? There are three keys—the first being supported by the second and third: 1) understand the site and its context; 2) involve the right people, including the appropriate mix of individuals who can address sociopolitical and biophysical issues; and 3) learn from the literature and past precedents.

The importance of integrating research and design, of preparing project teams "to be instructed during the process," and of developing evaluation criteria during project planning, is highlighted by river restoration experiences in California, where unfortunately many projects have lacked clear objectives consistent with geomorphic and ecological dynamics. As a result, many projects have been ineffective or harmful to aquatic and riparian resources. Effective river restoration requires real understanding of geomorphic and ecological processes (based on adequate study of the channel history, catchment-level influences for the site, and analysis of flow records), rather than application of "cookbook" approaches based on mimicry of form (Kondolf 1998). Ecological restoration of highly dynamic systems such as streams and rivers must be approached using in-depth analysis of evolving on- and off-site conditions. As Galatowitsch (1998, 102) notes, "Knowledge available for ecological design would greatly increase if designed landscapes [especially ecological restoration projects] were used as ecological research sites."

As a result of looking closely at past ecological restoration projects associated with streams and rivers, Palmer et al. (2005, summary) discuss five criteria for measuring success in river restoration, and emphasize the importance of an ecological perspective to restoration efforts. "First, the design of an ecological river restoration project should be based on a specified guiding image of a more dynamic, healthy river that could exist at the site. Second, the river's ecological condition must be measurably improved. Third, the river system must be more self-sustaining…so that only minimal follow-up maintenance is needed. Fourth, during the construction phase, no lasting harm should be inflicted on the ecosystem. Fifth, both pre- and post-assessment must be completed and data made…available."

They also express concern that many so-called ecological restoration projects are done under the banner of improving environmental conditions, yet these projects actually degrade ecological structure and functions, often because the proposed and implemented actions were inappropriate for local geomorphic and ecological conditions.[4] One of many examples highlighting this fact is a project that sought to restore a meandering stream in a location where geomorphic conditions precluded this type of pattern. The so-called stream restoration washed out and returned to its braided form soon after construction (Kondolf *et al*. 2001).

The problem with not recognizing the underlying structure and function of the landscape, nor the trajectory of both the larger landscape and the specific ecosystems of interest, is that a great deal of time, money, and sociopolitical capital can be wasted. This is not to say that thorough analysis precludes the making of mistakes. Nevertheless, major mistakes should occur less frequently. Given the great complexity of interactions occurring within ecosystems, we need to approach restoration efforts with humility, and treat our work as living, dynamic experiments.

Accounting for the findings from our monitoring and assessment of biophysical, ecological, and human factors, we need to consider what is possible, what is feasible, and what is expedient. This is yet another reason landscape architects need to work collaboratively with ecologists and other technical experts related to the ecosystems and landscape of interest.

For example, it may be possible to restore a floodplain wetland that has been "silted in" over many years by removing the sediments lying on top of the original wetland

---

4 For more on evaluation standards, refer to "Why the need for ecological standards" (Palmer *et al*. 2005). For more on assessment protocols, USEPA's Rapid Biological Assessment Protocols are particularly useful for monitoring streams and rivers during the planning stage of ecological restoration efforts (refer to "Selected Websites").

soils. However, we must first ask if this work is feasible given property ownership and available resources, and if it is expedient given the expected amount and type of flows into the area (which may include additional sediments and invasive species). Scientists and other partners can help planners and designers critically think through and effectively address these kinds of questions.

In the urban context it is rarely possible to restore a segment of stream to pre-development conditions. Given up-stream urban development (existing and/or expected), we must ask if our efforts will be adversely affected by increased rates of stormwater runoff from above our project site as well as by more intense or frequent flooding over time. As a designer, our desire may be to restore the stream channel to pre-development conditions, but this ideal may be neither feasible nor expedient. A better approach may be to work with property owners along the entire length of the stream to reduce stormwater inputs and to restore the riparian corridor by using various best management practices, including location-appropriate planting/seeding and bank stabilization.

The constraint of existing and future urban development need not put a halt to our restoration aspirations. Nevertheless, we must account for urban influences and choose those tools and techniques that are most likely to work over both the short and long term.

To account for changing urban influences, we recommend the following steps, which parallel the ideas noted on page 5: 1) Learn what the past ecological history of the area was; 2) consider the likely influences of existing and future urban development on the proposed restoration project; 3) assess whether ecological restoration is feasible and expedient; 4) if ecological restoration is considered feasible and expedient, establish specific goals and measurable criteria for success; and 5) establish monitoring protocols to measure the success of the implemented ecological restoration effort.

Photos 3 & 4. Coastal Louisiana Wetland Restoration efforts highlight the dynamic and technical nature of many large-scale ecological restoration projects. Here, landscape architects frequently interact with geomorphologists, biologists, engineers, and representatives from local parishes.
Photos courtesty Lee R. Skabelund

Critical Site-Related Issues in the Restoration of Functional Ecosystems

In addition to accounting for ecological variables, the practice of restoring functional ecosystems is strongly influenced by economic, sociocultural, aesthetic, and political dimensions related to the development, use, ownership, and management of land and water. To effectively respond to these complexities, ecological restoration teams must:

A. Understand the way ecosystems function in modified landscapes, including how specific organisms function within urban settings. This understanding comes through close observation and scientific study, and necessitates collaborative work between designers and scientists where ecological restoration is a stated goal.

A number of journal articles discuss the scientific questions that typically challenge ecological restoration practitioners and indicate how restoration ecologists can assist in answering questions related to restoration planning/design, soil development, genetic selection, biotic establishment, and project evaluation (Clewell and Rieger 1997).

To successfully implement ecological restoration programs and projects, we need to learn which ecological restoration practices work well, which do not, and what can be done to improve restoration methods for new projects. Scientists and others who keep abreast of restoration literature can help landscape architects keep current and help move restoration projects toward successful resolution.

B. Effectively address ecological functions by working with team members who understand the significant interactions for the ecological settings we work within.

Part of the essential science that practitioners of ecological restoration need to be familiar with is how larger landscapes function and change in space and time. The flows of wind, water, seeds, wildlife, sediments, and other materials between ecosystems and across landscapes are of particular importance as we determine the most appropriate restoration strategies for a site or ecosystem.

As noted in a number of the diagrams presented by Dramstad, Olson, and Forman (1996) in their book *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning*, these flows and other ecosystem processes are interrelated to the biophysical structure and patterns of a particular landscape. While patterns influence processes, flows can also strongly influence ecosystem and landscape structure. Additionally, natural and culturally-derived disturbances influence flows, structure, succession, and community assembly (Temperton et al. 2004).

C. Select specific ecological restoration targets based on a knowledge of past, present, and future (likely or expected) impacts and influences.

"A fundamental aspect of ecosystem restoration is learning how to rediscover the past and bring it forward into the present—to determine what needs to be restored, why it was lost, and how best to make it live again" (Egan and Howell 2001, 1).

Knowing what went on in the past will help us to better understand how disrupted or degraded soils, seedbanks, hydrology, biota, and other ecosystem components are—and what we will need to do to assist in their recovery. An analysis of historical changes can provide the essential context within which to develop and evaluate restoration actions. For example, an historical–geomorphological–ecological analysis can aid restoration in three principal ways: 1) improving our understanding of the underlying problem (if indeed there actually is a problem); 2) establishing realistic and ecologically and socially meaningful restoration objectives; and 3) selecting appropriate strategies to achieve those objectives. Both existing and projected impacts and influences must be addressed—otherwise our restoration efforts may be undermined in years to come.

Key Components of Effective Ecological Restoration

In discussions with selected experts in ecological restoration[5] important themes emerge, reinforcing ideas presented in this paper: the need for effective collaboration and communication between other disciplines, relevant agencies, clients, stakeholders, the public, and planners/designers; the establishment of clear goals at the outset of the ecological restoration project—basing project goals on a realistic appraisal of what is feasible given current and expected conditions in the area and region; the need to be explicit about desired future conditions and to establish measurable performance standards related to project intentions, goals, and objectives; recognizing that invasive species monitoring and management will likely be a part of each ecological restoration effort; and the need to build the institutional infrastructure necessary to manage a restored site, ecosystem, or landscape over time.

Per these professionals, ***indicators of "successful ecological restoration" include two primary outcomes: 1) the project's effectiveness in meeting stated project goals, objectives, and performance criteria, and 2) the ability to create a system that functions in accord with desired ecosystem attributes and conditions.***

---

5 Personal communications included discussions with the following ecological restoration experts: D. Apostol, K. Bowers, A. Clewell, D. Denison, C. Franklin, B. Johnson, C. Johnson, staff with the Louisiana DNR (K. Bahlinger, G. Grandy, and K. Lovell), D. Morrison, J. Patchett, J. Rieger, J.N. Roberts, J. Royster, and staff at Vigil-Agrimis (P. Agrimis, L. Herbon, T. Johnson, M. Klau, M. Raad, J. Richards, R. Ruggiero, R. Makie, L. Mark, E. Schulz, K. Vigil, and A. Zucker). Refer to Appendix C: Questions Reviewed by Ecological Restoration Experts—Fall 2005.

Other indicators in defining the "success" of ecological restoration projects include the following: employs aesthetics to create pleasing human experiences; is acceptable to the client, stakeholders, and the public; initiates sustainability of the restored site/ecosystem/landscape (promoting the system's capacity to adapt to its particular setting—ecological and sociopolitical); is productive, regenerative, complex/biodiverse, and dynamic; is properly designed, implemented, managed, and monitored (uses appropriate references and specifies appropriate materials, employs appropriate tools and techniques, and is enjoyed and cared for over the long term); optimizes multiple benefits (provides recreation opportunities, creates aesthetic, spiritual, and educational value, enhances ecosystem services); uses resources (ecological, cultural, and financial) efficiently and wisely; brings different disciplines together in a meaningful learning process; and helps leverage funds for other conservation and restoration work.

In the paragraphs below five "key components of effective ecological restoration" are discussed.

Project teams must 1) develop appropriate inventory and analysis protocols for investigating existing conditions; 2) establish appropriate goals and criteria for projects in urbanizing contexts; 3) define appropriate reference ecosystems and pre-restoration monitoring needs; 4) determine short-term post-construction monitoring, management, and evaluation needs; and 5) address exotic species by developing workable plans for invasive species controls.

1. Developing Inventory and Analysis Protocols for Investigating Existing Conditions

Given that each site, landscape, and set of ecosystems is unique, the development of a protocol for inventory and analysis work is essential when investigating existing site/ecosystem and landscape conditions. Particular attention must be given to the structure and function of and the interactions between hydrology, soils, vegetation, and wildlife. Determining the causes of factors leading to degradation and determining what can be done to remedy both the causes and results of degradation should be undertaken at various scales and from multiple perspectives.

The overriding idea that should guide inventory and analysis work is to understand and treat the problems, not the symptoms. Because many projects have barely enough money for design work, let alone a comprehensive level of analysis, much can be accomplished by landscape architects who make the time to become educated in landscape ecology, conservation biology, and restoration ecology.

2. Establishing Appropriate Goals and Criteria for Projects in Urbanizing Contexts

The importance of goal setting in ecological restoration cannot be overstated. For restoration to be called "successful," project goals must be specifically and clearly defined, and the goals achieved through subsequent planning, design, restoration/

management, and monitoring. Below are suggestions regarding goal-setting from landscape architects and other practitioners actively involved in ecological restoration planning and design:

Keith Bowers, president of Biohabitats in Maryland (2005, pers. comm.) indicated that successful ecological restoration effectively addresses ecological, social, and economic issues by, for example, restoring livelihoods, helping retain or restore clean potable water supplies, creating regenerative agricultural practices, or restoring vibrant ecological systems. Bowers noted that "we are still trying to figure out what success means. In the interim, we need to be clear about what we see as our criteria for success project by project, and these criteria must necessarily be linked to specific project goals."

Carol Franklin, principal at Andropogon Associates, Ltd. in Philadelphia (2005, pers. comm.), indicated that project goals should be broad and holistic enough to make them relevant, and that designers should help ecological restoration teams meaningfully address human experiences and aesthetics. Franklin mentioned several very important ideas:

Planners and designers must open our eyes to a place—helping us to really understand its patterns and functions. As designers, we need to be faithful to patterns and processes by carefully considering what works for the particular place, time, and context.

Designers can use "plant communities" and "habitats" to assist them in designing appropriate ecological restoration projects. Designers should reveal transitions between plant communities, be they abrupt or gradual. Designers should also consider micro-climates, micro-responses, and micro-places to build a series of experiences for those who use or visit the place.

Orchestrate complexity back into landscapes. Provide for clear and understandable structure but not simplistic (over-simplified) structure. Create appropriate transitions and unified compositions. Restored sites should be beautifully organized and express good design.

John Royster, president of the Big Muddy Workshop in Omaha, Nebraska (2005, pers. comm.), said that restoration practitioners need to define specifically what the desired outcomes of the project are and tie each of these outcomes back to what the client can and can't do over the long term. "Do your historical research, as you must first know that what you are actually trying to restore was actually there. Otherwise our work is simply creation or planting design." He noted that if a project goal is to educate the public about ecosystems native to the place, then a hallmark of the project would be to provide valuable education—of public and clients—regarding local ecosystems.

Bart Johnson of the University of Oregon (2005, pers. comm.) recommends developing a realistic appraisal of what is feasible given current and expected conditions in the area and region, then clearly define what is to be restored in terms of ecosystem structure, composition, and functions. "Be explicit about the future conditions desired and establish measurable performance standards."

Kenneth Bahlinger, Greg Grandy, and Keith Lovell of the Louisiana Department of Natural Resources (2005, pers. comm.) indicated that successful restoration efforts meet clearly defined project goals, and that these goals need to be defined early on—with monitoring considered during the planning and design process so as to be integrated with design, construction, and planting.

3. Selecting Reference Ecosystems and Determining Pre-Restoration Monitoring Needs

A reference ecosystem is one with attributes similar to the one being restored and serves as a guide for ecological restoration planning/design and implementation. A reference ecosystem "serves as a model for planning a restoration project, and later for its evaluation. In its simplest form, the reference is an actual site, its written description, or both" (SER 2004, Section 5).

A reference site has attributes very similar to the type of ecosystem that the project team is attempting to restore. The problem with selecting a single reference site is that it may be viewed as a single, somewhat static state and may not adequately reflect the various conditions a project team might deem acceptable. Thus, a reference ecosystem "is best assembled from multiple reference sites and, if necessary, other sources. [This] composite description gives a more realistic basis for restoration planning" (SER 2004, Section 5). Although a composite description is ideal, time/budgetary constraints may necessitate use of a single reference, and in some locations (for example, highly developed, rapidly developing, or agricultural landscapes) good references may be difficult or impossible to find.

A composite approach has been developed and used in Germany for over 15 years for stream restoration projects, where for each region of distinct geology and climate, a set of valley and stream types is identified (Kern 1992). These are used to help develop restoration targets in the form of a *leitbild* or "guiding image." The *leitbild* is not simply the historical, pre-disturbance condition, but rather an articulation of the best possible ecological condition for the stream given its geographical setting and the irreversible alterations that have occurred to its watershed (Kondolf and Larson 1995).

Our suggestion regarding selecting references: Do as much as can be done given the constraints your team is working under—seeking to use a "multiscale, multisource, cross-referential historical analysis that is compared to contemporary data" (Egan and Howell 2001, 14).

The following sources of information can be used to describe a reference ecosystem:

- ecological descriptions, species lists, and maps of the project site prior to damage;
- documents describing regional flora and other publications or maps of regional and/or local vegetation;
- historical and recent aerial and ground-level photographs;
- remnants of the site to be restored, especially those indicating previous physical conditions and biota;
- ecological descriptions and species lists of other similar, intact ecosystems;
- herbarium and museum specimens;
- historical accounts and oral histories by persons familiar with the project site prior to damage; and
- paleoecological evidence, for example, fossil pollen, charcoal, tree ring history, rodent middens.

(Source: Egan and Howell 2001)

The value of a reference increases with the amount of quality information it contains, but as noted above, every inventory is limited by time, funding, and access to useful information.[6] Once one or more reference sites are selected, then a baseline inventory of the site (or sites) can be undertaken. "Minimally, a baseline ecological inventory describes the salient attributes of the abiotic environment and important aspects of biodiversity such as species composition and community structure" (SER 2004, Section 5). Additionally, a baseline ecological inventory identifies "normal periodic stress events" (for example, fire or flooding), which traditionally maintain the integrity of an ecosystem (SER 2004, Section 5). Descriptions of the reference for cultural ecosystems or ecosystems within urban settings should identify the cultural practices critical in restoring and managing that ecosystem.

Written restoration project goals are critical for determining the detail needed in the description of the reference. Where general goals are appropriate and prescribed, the

---

6 Describing "a reference is complicated by two factors that should be reconciled to assure its quality and usefulness. First, a reference site is normally selected for its well-developed expression of biodiversity, whereas a site in the process of restoration typically exhibits an earlier ecological stage. In such a case, the reference requires interpolation back to a prior developmental phase for purposes of both project planning and evaluation" (SER 2004, Section 5). It should be noted that there is less of a need for interpretation where the developmental stage of vegetative communities on the proposed restoration site are sufficiently advanced for direct comparison with the reference, as in the case of woodland restoration, where invasive species are simply being removed from a mature forest setting. "Second, where the goal of restoration is a natural ecosystem, nearly all available references will have suffered some adverse human-mediated impacts that should not be emulated. Therefore, the reference may require interpretation to [highlight] these sources of artifice. For these reasons, the preparation of the description of the reference requires experience and sophisticated ecological judgment" (SER 2004, Section 5).

description of a reference can be equally general. In such instances, aerial photographs may represent the most important source of information for the preparation of the reference. Restoration at a finer scale (or for more scientifically oriented project efforts) may require more detailed reference information, such as baseline inventory data collected on-site in small plots or along transects. In some instances (for example, in highly developed or disrupted settings and where detailed written descriptions and other records are not available) data from on-site plots or transects may be the only reference points that ecologists, planners/designers, and other team members have to work with (SER 2004, Section 5).

Pre-restoration monitoring on the site (or area) to be restored is an essential task if before-and-after conditions are to be objectively measured and evaluated. Although urban planning/design schedules and budgets are generally made without consideration of pre-monitoring of project sites, this standard operating procedure must change if we are to scientifically assess and evaluate changes that occur after a project is implemented. Thus, an important charge for project team leaders is to secure the necessary funding for pre-monitoring work and to determine specifically what can be monitored before implementation of restoration work begins.

For example, if we are seeking to restore water quality within an urban stream to some known or estimated pre-existing condition, then we need to sample the water at various times of the year (ideally for more than one year) in order to understand and respond to existing conditions. If a project team simply determines to record before-and-after conditions visually (a common but less scientific approach), then they still need to determine the best places and times to record photographs so that results will be objective, consistent, and meaningful.

In summary, we should select reference systems that are realistic in terms of our project site's current conditions and context as well as its potential landscape trajectories. We should also develop reference documentation and undertake pre-monitoring to support project goals.

Photos 5 & 6. Tom's Creek Riparian Corridor Restoration—Blacksburg, Virginia. The guiding image for this project was to restore protective stream corridor, with a canopy of trees and shrubs native to the Ridge and Valley eco-region of southwest Virginia. *Photos courtesy Lee R. Skabelund.*

4. Determining Post-Construction Monitoring, Management, and Evaluation Needs

There are a number of important post-construction monitoring, management, and evaluation needs in the weeks and months following installation or completion of a restoration project. Recognizing these needs upfront allows for adequate resources to be secured. Properly planned ecological restoration projects seek to fulfill clearly stated goals that reflect important attributes of the reference(s) and proposed ecosystem types. Goals are attained by pursuing specific restoration objectives. The goals are ideals, while objectives are concrete measures taken to attain these broader goals.

Because the number of ecosystem variables that can potentially be used in an evaluation is too great to be measured within a reasonable period of time, selection of variables to assess and variables to ignore requires a value judgment. "Two fundamental questions should be asked with respect to the evaluation of a restored ecosystem. Were the objectives accomplished? Were the goals fulfilled? Answers to both questions gain validity only if the goals and objectives were stated prior to implementation of restoration project work" (SER 2004, Section 7).

Project objectives should be evaluated on the basis of performance standards, also known as design criteria or success criteria. Performance standards should be developed in large part from an understanding of the guiding image or reference ecosystem. Performance standards provide an empirical basis for determining whether or not project objectives have been attained.

Objectives, performance standards, and protocols for monitoring and data assessment should be incorporated into restoration plans at the early stages of a project. Because unanticipated environmental conditions can alter the restoration trajectory, and since goals are ideals that cannot be perfectly measured, an element of professional judgment and subjectivity is inevitable in the evaluation of project goals. If monitoring shows that standards or criteria have been met, then a project can be called a success (SER 2004, Section 7).

The evaluation of ecological restoration efforts must include the assessment of goals and objectives pertaining to cultural, economic, and other sociopolitical factors. To assess these factors, evaluation tools used by social scientists may be especially helpful—for instance, working groups, interviews, or preference surveys of local residents or population subgroups (Kaplan et al. 1998). Assessing the views of stakeholders and policy makers is helpful for future project efforts as well.

 

Photos 7 & 8. Oak Savanna Restoration—Minneapolis, Minnesota. This project, high on the bluffs overlooking the Mississippi River, sought to restore ecosystems typical of ecosystems observed along the river in the past, while also accommodating present and future recreation needs. *Photos courtesy Lee R. Skabelund.*

5. Addressing Exotic Species by Developing Plans for Invasive Species Controls

The impact of invasive, non-native species on landscape and ecosystem integrity is likely to provide many challenges to those interested in maintaining or restoring the health and diversity of natural ecological systems. One of the primary ways that planners and designers can assist is by wisely planning, designing, and specifying proposed interventions of all types—namely, by reducing human disturbances on intact natural systems and avoiding the establishment of additional invasive, non-native species.[7]

As a rule of thumb, planners and designers should not use invasive species in any of their planting plans or other designs, not even in urban settings, since wind and water can spread seeds and other propagules far and wide. Landscape architects/designers should also encourage suppliers to provide native species,[8] and to not market or sell

---

7 A frequently made mistake for designers without botanical experience is to assume that plants from a "native plants nursery" are native to the project being worked on. Similarly, plants indicated as being "native to the U.S." are sometimes assumed to be appropriate for all sites in the United States. "Native species ranges must be checked through botanical publications and range maps…which are typically made on a county-by-county basis." The decision as to whether a plant is native to a site must also include an assessment of its relationship to the soil type and moisture levels, sun/shade exposure, local ecological community presence, etc. (Anonymous reviewer 2005).

8 Per the USDA, NRCS PLANTS Database, "native" has a specific meaning. The following is adapted from the "Frequently Asked Questions" section of the PLANTS website (*http://plants.usda.gov/faq.html#native*): ***Q. What do you mean by native and introduced?*** A. "***Native***" means naturally occurring in North America and the U.S. and its territories at the time of Columbus; "***introduced***" means arrival from some other part of the world since Columbus's time. "***Naturalized plants***" are introduced plants that now exist in the wild without assistance from humankind; these are called "introduced" since this term is more familiar to most people than" naturalized." "***Native and introduced***" applies to species with both native and introduced varieties or subspecies; if a plant is native to one part of the U.S. and introduced in another, it is coded as "native" in the PLANTS Database.

invasive species. There are many suitable native and non-invasive ornamental plant species that can be used in place of known or potentially invasive species.

The "St. Louis Declaration" on invasive plants discusses six major principles that can guide our efforts to manage invasive species, namely:

1. seek to minimize unintended harm;
2. consider national goals and the region-specific context;
3. use prevention and early detection as primary controls;
4. use research, education, and training to broaden and deepen our collective understanding of problems and solutions;
5. involve individuals from all fields and professions to help control invasive species; and
6. employ codes of conduct, best management practices, and regulation to address local, regional and national invasive species concerns.

Source: *www.centerforplantconservation.org/invasives/mbgN.html*

If invasive species are on or near a site proposed for restoration, then planning for ways to eliminate or otherwise manage these species will likely be a necessary or desired project goal.

Reed (2004) discusses the importance of identifying and mapping specific areas of concern and describing the types of invasive species that are present within a site (or that may establish themselves from surrounding areas). She also describes three ways to stop or slow invasions, namely: 1) prevent invasive propagules from entry by minimizing disturbance of intact ecosystems (conservation) and by avoiding the use of contaminated materials (namely, seed mixes, strawbales, mulches, topsoil, and fill dirt); 2) prevent germination and establishment of invasive species by eliminating aggressive invasives prior to initiating required management or development disturbances, ensuring coverage of bare soils (for example, by helping to close the forest floor using native forbs, grasses, and shrubs after forest restoration is initiated), and regularly monitoring and removing species that pose a threat on restored sites; and 3) maintain natural processes, especially those related to promoting healthy soils and hydrology.

Basic steps in controlling invasive species include the preparation of a descriptive "inventory and management plan" followed by appropriate use of mechanical, cultural, biological, and chemical controls. Controls to be used depend on the particular species of concern and the landscape–ecosystem context. Invasive species controls may include: herbicides, biological controls, hand pulling, mechanical clearing and/or cultivating, and the planting of native species that will out-compete or succeed the invasive species. Caution is required since herbicides, biological controls, and mechanical clearing/cultivating may pose adverse environmental effects and could potentially raise sociopolitical concerns and project opposition. Soil disturbance frequently encourages growth by invasive species.

Removal of invasive species must be coordinated with effective replacement by other desirable vegetation, otherwise removing invasives may be worse than living with these pests. This said, "living with invasives" means managing invasive species for acceptable levels of coexistence with native species when extirpation of invasive plants or animals is not feasible given our present limitations in knowledge, time, personnel, and budgets.

The phasing and removal of invasive plant species must also consider the potential impact on animals that use these plants for food or cover. If rare, threatened, or endangered species have come to rely on invasive species for food sources (as with the endangered willow flycatcher and the imperiled snail kite that now nest in *Tamarix* and *Melaleuca*, respectively), then removal may not be acceptable or legally allowed. In instances such as this, coordination with responsible agencies will be essential (D'Antonio and Meyerson 2002).

Even if all invasive species are removed from a restoration site, the opportunity for re-invasion may remain high. Therefore, it is essential to establish priorities based on sound science.

Highest priority should be given to the control or extirpation species that pose the greatest threats—and in most cases early eradication is ideal (Simberloff 2003).

Invasive plant species that are particularly mobile and pose an ecological threat at landscape and regional levels, and animals that consume or displace native species, are of greatest concern. Care must be taken to cause the least possible disturbance to soils, habitats, and indigenous species as invasive species are removed (May 2001).

Planners and designers need to work very closely with scientists and professionals from other disciplines in order to understand the nature of the problem, to develop reasonable goals and objectives, and to achieve success in invasive species management. "Voluntary Codes of Conduct for Landscape Architects" were developed as part of the St. Louis Declaration and include the need to continually educate ourselves about invasive species concerns and best management practices. Planners and designers should use appropriate non-invasive plants in their designs,[9] promote

9 If landscape architects desire to proactively address invasive species concerns, they should incorporate ecological restoration protocols into their project work as appropriate to specific project scenarios. Protocols could include the following: (1) Exclude the use of all known invasive species (2) Choose native species over exotics and cultivars where projects abut natural areas. If feasible, exclude the use of exotic species or cultivars in areas within 1000 feet of natural areas or eliminate them from planting plans altogether (3) Where large area plantings are implemented (especially for mine, landfill, and other disturbed land reclamation work, creation of wildlife habitat, soil erosion control, or visual/noise buffers), use native plant/ecosystem restoration specifications (Anonymous reviewer 2005).

the propagation and supply of non-invasive plants by nurseries and contractors,[10] and help develop and/or revise local landscape ordinances to appropriately address invasive species concerns.

Addressing the Sociocultural and Political Dimensions of Restoration Design

In the first issue of the scientific journal *Restoration Ecology* (1993), John Cairns, Jr. asked the question: Is ecological restoration practical? His answer was yes, with the following caveat: "Without societal support, long-term landscape-level restoration will almost certainly not succeed. Therefore, while the science and practice of ecological restoration are developing, the public must be acquainted with the choices and challenges" associated with this important field (Cairns 1993, 6). Even if all important ecological factors have been successfully accounted for during ecological restoration project planning, sociocultural and political factors can negatively affect or undermine project goals, procedures, and outcomes. As a result, accounting for and addressing potential social, cultural, and political conflicts is imperative.

The following paragraphs address ways to approach conflicting sociopolitical interests and mandates, deal with interdisciplinary differences, and resolve conflicts related to public and stakeholder interests.[11]

Political mandates can be frustrating, especially when sociocultural or political preferences for a certain landscape solution appear to be contrary to what we understand a site should become through our ecological restoration efforts. What can we do? Engage in constructive dialog early, and learn the key concerns of stakeholders with influence on the final decision-makers for a project. Look for opportunities that are win–win. Remember that "means" (approaches) are important too, and that a compromise today may open the door to improved restoration tomorrow.

The public should be considered in ***all*** projects[12]—if for no other reason than that most restoration projects have some type of public or foundation funding. When input is sought, it needs to be responded to, even if what we hear from stakeholders is not consistent with what we believe to be best as professionals. Landscape architects

10 Because commercial availability of native plants is not uniform and many native species are either not propagated or are propagated in limited numbers, landscape architects and other planners/designers "must go beyond the limitations of existing nursery stocks to find ways to re-create historic plant diversity rather than depending solely on available nursery stocks and the use of substitution lists" (Anonymous reviewer 2005). This may mean obtaining permission to collect seed from approved seed harvesting sites.

11 This section draws heavily from Fall 2005 discussions with Dean Apostol, Keith Bowers, Carol Franklin, Bart Johnson, Darrel Morrison, Jim Patchett, John Rieger, John N. Roberts, John Royster, and staff at Vigil-Agrimis.

12 In some instances, such as mitigation banks, active public involvement may not be appropriate or needed.

should seek to be inclusive, but must recognize that the public involvement process can increase the cost of a project substantially, and public participation may not always add clarity to the design. Go slowly when this is possible. Be judicious about how and when to be assertive in efforts to steer proposed designs or management. Listen closely; sometimes solutions are found in what is not said. Be open to perspectives different from our own. Seek to learn from local residents who have a deep understanding of local ecosystems.

Project team members need to hear people out. If others are or seem to be simply "wrong," show them what you perceive to be "right." Never let someone talk you into doing what is clearly wrong. If people do not agree with the team's restoration approach, be tactful, tread lightly, and retain a sense of humor. Don't pretend to know what you don't. Restoration is about discovery. Let people learn by participating and exploring. Remember that ecological restoration is not an ego-driven enterprise. Listen and share our strengths. Learn when to ask for help.

Conflicts are often made too much of. There are always common goals and interests; most people agree on a large percentage of ecological restoration issues, whereas a small percent of ecological restoration issues may present real conflict. Many of these contested issues can be addressed by creative physical planning and design. Some issues may simply need to be fairly aired in client meetings and public forums and decided on by elected officials or other designated decision-makers.

To effectively address conflicts, planners/designers need to be committed to process. The process can be short-circuited by individual preferences. We should not design by ideology, but by a solid understanding of people and place. Ask: What spatial and aesthetic qualities can be restored or created, and how do we integrate ecological restoration into the urban setting? Look for the points of agreement and disagreement, and understand why there are disagreements. Ask: What issues need to be worked out, and how can planning/design tools assist us to effectively address these issues?

In dialogue with other disciplines, landscape architects need to carefully consider when, where, and how ecological restoration really makes sense (in some circumstances it is not likely to succeed). To address potentially conflicting restoration mandates, project teams need to coordinate early in the process, communicate often, continually seek to establish common ground, creatively explore alternatives, and encourage agencies, stakeholders, and other participants to be flexible and willing to try new approaches.

Creative design can be an important part of conflict resolution, especially as we seek to build common ground between scientific, aesthetic, and recreation interests. The role of landscape architects is to help get these values and ideas in front of the decision-makers—be they the public or elected officials/politicians, recognizing that there will be trade-offs. Planners and designers can help determine how potentially conflicting issues and goals relate to one another. We can also help the public, stakeholders, the general public, scientists, and other team members visualize the implications of specific project goals that are under consideration.

Because ecological restoration cannot be achieved without effective collaboration among relevant disciplines, we must communicate and work together effectively. For example, one of the first questions biologists/ecologists often ask for a restoration project is "What is your target species?" Scientists and land managers may focus on specific plants or animals. Planners and designers generally approach projects from the visitor's or user's vantage point (aesthetics, recreation, and education are often thought of as being most important). These differing interests can create conflicts. There are also conflicts regarding what we can and cannot control, so we need to think about general ecosystem health, recognizing that once initiated, various kinds of forces will ultimately shape these places. In the end, we must recognize that we can help shape ecosystems, but we cannot completely control them.

Public support is essential. Since residents are a great source of creative energy, information, and long-term support, they need to be involved at the outset. Where possible, giving the public an opportunity to participate, hands-on (with invasive removal, site preparation, and planting) can generate strong public support.[13] Because ignoring stakeholders can lead to animosity and vandalism, we need to seek to understand and accommodate stakeholder needs and desires by making the restoration planning/design process transparent (or open)—welcoming input, ideas, and criticism.

---

13 Anytime we meaningfully involve the public and stakeholders in ecological restoration this creates support; people feel good because they perceive that they are making worthwhile contributions. Such involvement establishes advocates for project approval, protection, and ongoing management efforts, as well as for funding support. Public participation also creates a volunteer base that can assist with future restoration and management activities. Hands-on work and volunteer days serve as social events and build community associations. To involve people, we need to publicize what we are doing, explain and discuss important issues in multiple ways (verbally and in writing); create on-site interpretation (geared to children, youth, and adults); pull in scouts, service organizations, and other groups; and be creative in vesting people in project work.

Planners/designers can learn much from local citizens. Stakeholders may have anecdotal information that can be of great benefit, for example, providing ideas about how to relate an "ecological approach" to ecological restoration *with* human use.[14]

Some participants may view existing landscapes as static entities, wanting to keep places as they are in perpetuity. Project teams need to consider the role natural disturbances such as drought, fire, flooding, and other dynamic processes will be allowed to play on a restoration site (insofar as these can actually be controlled) and how to communicate the project goals.

Education of the public, practitioners (including developers and engineers), and local governments is a necessary part of each project. Educational methods that clearly spell out the potential values of restoration, including aesthetic and recreational values, will often be necessary to gain public acceptance. There are multiple benefits for participants, including ongoing enjoyment and learning about how natural systems function.

Although the public can help in many ways, including approving or disapproving of certain ecological restoration goals, plans, designs, and implementation/management strategies, there needs to be a clear decision-making process for a project. Protocols for when science will rule and how it will be used in relation to democratic decision-making are very important. Early on, a decision-making tree can be developed to clarify public, scientist, planner/designer, manager, and policy-maker roles.

Non-profits and local governments (*e.g.*, The Nature Conservancy, nature preserves, natural area managers, state agencies, parks and public works departments, and others) often play vital roles in managing natural areas and restoring ecosystems. Citizens can volunteer to be trained as public stewards and help with volunteer activities. Coordinators are needed and dedicated residents can help with stewardship programs. We need to know what residents like and dislike so this can be accounted for in planning/design recommendations, education programs, and management efforts.

---

14 With their knowledge of the land and their technical skills, loggers, farmers, and other local people who work or know the land can help restore local ecosystems. Through our projects we should consider ways to create "working-and-living landscapes" — places where the regenerative harvesting of native species and managing invasive species help support local economies and connect people to the land. Leslie Sauer's book, *The Once and Future Forest: A Guide to Forest Restoration Strategies* does an excellent job of addressing public (community) involvement in ecological restoration. James Fogerty's discussion of the use of oral history (as found in *The Historical Ecology Handbook: A Restorationist's Guide to Reference Ecosystems*) is likewise of value when considering ways to involve local residents and other potential participants. Franklin (1997,1999), Lambert (1999), Barro & Bright (1998), Ehrenfield (2000), Grese et al. (2000), Throop (2001), Higgs (2003), Jordan (2003), Folke (2004), France (2006), Bowers (2006a, 2006b); Hawken (2007) each reveal ways to reconnect urban residents with ecosystems and promote effective community participation during ecological restoration planning/design.

It is important to thoughtfully evaluate what role the public should have and could have. Ask and address the question about what is appropriate for each ecological restoration project, and recognize that the answers may be different depending on the site, the context, the landowner, the stakeholders, project goals and objectives, etc. It is very hard to effectively address all conflicts. As a result, ongoing effort, creativity, effective communication, and meaningful collaboration are essential.

Photos 9, 10, and 11. Woodland Restoration and Invasive Species Management at Furstenberg Park in Ann Arbor, Michigan, have been greatly aided by volunteers working in tandem with Natural Areas Preservation Division staff and other local restoration experts. Biologists were part of the landscape architectural team that completed a site analysis and prepared restoration plans.

VI. How Landscape Architects Contribute to Ecological Restoration Efforts

Given the fact that restoring ecosystems can be very complex, multiple disciplines are typically involved in an ecological restoration project. The primary bases of knowledge typically required for successful ecological restoration efforts include ecology, biology, geology, soils, hydrology (water), botany (plants), and other sciences. Other disciplines and skill sets that may be involved include anthropology, natural history, stakeholder facilitation, landscape modeling (GIS), engineering, construction management, and environmental education.

Landscape architects commonly have knowledge and skills in several of these areas, and, most importantly, they can integrate multiple disciplines and have experience in leading projects with diverse teams. Landscape architects also have the ability to help project teams, clients, stakeholders, and the public visualize what restored sites might look like and how restoration projects will be constructed. The ability to garner public buy-in and stewardship for these "new ecosystems" is essential. Landscape architects also have the capability to integrate public uses, the aesthetics of place, and interpretation—all critical for understanding and long-term success.

Additionally, a landscape architect's ability to create construction drawings, write specifications, coordinate contractors, and oversee the implementation of planning/design ideas throughout the construction process are essential skills for ecological restoration projects (Ryan 2002).

The composition of a team will depend on the project objectives and scope, by the amount and type of funding available, and by the timeframe in which the project must be implemented. Projects driven by salmon habitat restoration goals need fisheries biologists and fluvial geomorphologists on the team; prairie ecosystem restorations should include grassland ecologists/biologists as key players on project teams. For stream, river, and coastal restoration/reclamation projects, geomorphologists, hydrologists, and engineers are primary partners. Forest ecologists play a central role where forests are to be restored.

Clients and stakeholders (including community members where a site is publicly owned or neighboring residents and landowners where a site is privately owned) are considered to be essential participants.

Because many ecological restoration projects take place on public land, it is likewise useful for planners and designers to encourage team members to consider how restored ecosystems can potentially serve as important public gathering spaces. Cranz and Boland (2004, abstract) indicate that "sustainable parks" typically address the following issues: "(1) self-sufficiency in regard to material resources and maintenance, (2) solving larger urban problems outside of park boundaries, and (3) creating new standards for aesthetics and landscape management in parks and other urban landscapes." Planners and designers can play a vital role in helping local communities visualize how to integrate ecological restoration into parks and natural areas so as to increase visitor enjoyment and lower long-term maintenance and redevelopment costs.

Because some people do not think that native plants and natural ecosystems fit well within the urban context (they "look messy"), these ecosystems can be made more coherent and thus more appreciated as landscape architects help project teams implement "cues to human care" (Nassauer 1997, 77). As noted in *Placing Nature: Cultural and Landscape Ecology*, cues to care include mowing borders and pathways; creating tidy-looking fences and walks; including bright, attractive flowers; and trimming edges—each of these "used sparingly and placed strategically to frame ecosystems" for more enjoyable and appreciated human attention (Nassauer 1997, 78).

Frequently ecological restoration projects in urban settings involve landscape architects as project managers or as key players of the project team.

In determining the composition of our ecological restoration team, we need to decide who will be the primary leaders. Ideally, a person having practical experience and a strong scientific background related to the field of applied ecology should be involved in every project. This "ecologist" or "restoration practitioner" can be thought of as the principal investigator (someone who has the ability to help the team think through site assessment, restoration implementation, and monitoring and management protocols). A project manager (the person responsible for coordinating day-to-day activities and ensuring timely participation by project team members, primary stakeholders, the larger community, contractors, and sub-consultants) is also an essential leader on an ecological restoration project.

For small and less complex projects, the principal investigator and project manager may be the same individual and these roles could be held by a planner/designer. On large or more complex projects, a landscape architect with sufficient expertise in the field of restoration ecology could serve in one or both of these respective roles. What matters most is not what discipline leads, but that integration of knowledge from all relevant disciplines is effectively brought to bear on the project process and its outcomes. To be most effective, the project team must be familiar with both ecological restoration and restoration science.

VII. Selected Project Examples

There is an increasing body of ecological restoration work, creatively integrated into urban settings throughout the country. Examples can be found along the Hudson River in Manhattan's Riverside Park, within the Wildlife Conservation Society Bronx Zoo and the North Woods of Central Park in New York City, at Kenilworth Tidal Marsh along the Anacostia River in Washington, D.C., at Bair Island, Crissy Field, and Presidio Park in San Francisco, along Nine-Mile-Run in Pittsburgh, at Furstenberg Nature Park in Ann Arbor, Michigan, at Hitts Siding Prairie Nature Preserve in Wilmington, Illinois, along the Delaware River and at the 26th Street Gateway in Philadelphia, and at Avalon Park on the north shore of Long Island, New York.

Ecological restoration projects are highlighted in publications such as Ecological Restoration (*www.ecologicalrestoration.info/*) and at the Society for Ecological Restoration International website *(http://ser.org/project_showcase.asp#ShowcaseListing)*.

Additional insights and project photographs can be found through targeted Internet searches (as at the Restoring Rivers database—*www.restoringrivers.org/*), and by reviewing both public and private responses to restoration efforts (as with the restoration of tidal marsh and meadow habitats at Crissy Field along the San Francisco Bay (see *http://www.nps.gov/partnerships/rest_crissy_field.htm* and *http://philipsgardenblog.com/2008/08/19/crissy-field-urban-restoration-ten-years-later/* as examples). What is noteworthy about the Crissy Field restoration project is the detailed monitoring effort, which can be read at *http://www.parksconservancy.org/our_work/crissy/resources.asp* (refer to "Crissy Field Monitoring Report"—*http://72.5.117.155/dynamic/subpages/image_1_335.pdf*).

Appendix A provides Internet links to ecological restoration projects that may be of interest to landscape architects involved in planning and designing similar types of project work. References to books and articles are also provided in relation to specific projects or ecosystems.

Photos 12 & 13. The Crissy Field Wetland Restoration project in San Francisco, California, highlights the importance of effectively addressing potentially conflicting project goals, including the restoration of sensitive habitat and intensive recreation uses (where dogs, cats, people, vehicles, invasive species, and urban stormwater inputs have the potential to disrupt wildlife, simplify biological systems, and degrade restored ecosystems).

VIII. Successful Ecological Restoration: A Summary of Key Ideas for Practice

In working on ecological restoration projects in urban (or urbanizing) settings, landscape architects and their partners must deal with multiple constraints and competing objectives. The following ideas highlight important issues and help to establish a framework or process for addressing these concerns.

1) Learn from past projects and from the science of restoration ecology (e.g., the Primer on Ecological Restoration and Guidelines for Ecological Restoration by SER). Work with other disciplines to adapt these ideas to the specific project and bioregional context.

2) Consider the larger landscape and sociopolitical context, how this context influences a project, and how a project will likely influence its surroundings over time. Understand the key principles from landscape ecology regarding the interrelationships between landscape and ecosystem patterns/structure and ecological flows/dynamics, disturbances, and processes. Do sufficient inventory and analysis work before making important or final design decisions. Understand geomorphic and hydrologic processes, climatic and soil conditions (and how these are influenced by geology and landform), plant and animal species present or observed, and plant and animal interactions that may influence a project. Explicitly account for a site's ecological functions and its larger context in our plans, designs, and specifications. Recognize that inventory and analysis may take one or more years to really understand a project site.

3) Learn from other disciplines, working collaboratively to achieve ecological restoration goals. Seek the help of local experts, testing what we collectively understand during site visits, development of plans/designs, and implementation. Learn from our work (including mistakes and surprises) by keeping track of how the system looks (recording its patterns by photographs and quantitative assessment), how it functions, and how it changes over time.

4) Carefully choose references (models or guides) and precedents (other completed projects) that will enable us to establish appropriate ecological restoration goals and to employ effective implementation, monitoring, and management techniques. Think of ecological restoration projects as ongoing experiments and plan/design for feasible and place-appropriate monitoring and management activities.

5) Find appropriate metrics to assess the integrity of restored ecosystems. For example: How diverse is the restored area? What is its floristic quality? What percentage of vegetation is native versus exotic versus invasive? What changes are occurring in the soils and soil fauna? Document the decisions we make and the changes that occur as the restored ecosystem evolves. Evaluate the results and what we learn. Share

this information to obtain additional insights from external critics and to help others practicing ecological restoration.

6) Clearly and specifically define ecological restoration goals and how they relate to other planning/design goals and issues, including political, social, biophysical, and technical concerns. Be careful about how we use language as it can help or hinder our ability to successfully communicate with other disciplines and the general public about our design intentions as well as ecological restoration results. State assumptions and establish a vision, but don't make promises by saying we will restore something that we may not be able to. Consider the institutional capacity of a client or community to manage monitoring and management requirements over time and seek to increase this capacity to a sufficient level prior to or through the act of ecological restoration. It may require time to build an adequate volunteer base.

7) Whenever possible, involve the public in decision-making and project implementation, especially monitoring and management activities. Seek out and learn from local naturalists, historians, and others who know the regional and local landscape and how these places have functioned and changed over time. In terms of project process and products, ask, What are community members learning and how are they learning these things? Offer many different types of opportunities for community members and volunteers to help, and let them know that their contributions are genuinely appreciated.

8) Address invasive species issues intelligently. Review what has been written and learned about systems in similar contexts, assessing the pros, cons, and risks of different invasive species management tools and techniques. If there are concerns about the use of a particular strategy, proceed with caution (for example, waiting until more research and results can be reviewed or testing a strategy on a limited area). Coordinate with policy makers, adjacent landowners, stakeholders, and other disciplines to address invasive species issues.

9) Recognize that how a system functions is vital, but how it looks is also important. Help the general public appreciate less manicured landscapes and ecosystems. Build "cues to care" into a project, helping visitors and neighbors see that restored ecosystems are not "minimally useful" or "waste places." Help evoke a sense of place by employing principles from both restoration ecology and aesthetics (visual fitness and appreciation).

IX. Conclusions

Ecological restoration is a key to conserving vital ecosystems (MacMahon and Holl 2001).

Given uncertainties about the efficacy of ecological restoration efforts in or near urbanizing landscapes, some may ask, can we restore authentic natural systems in human-dominated areas? Biologist John Cairns, Jr. noted that "restoration can be achieved anywhere with any damaged ecosystem, and the prospects for sustainable use of the planet will be enhanced!" (1999, 9).

We concur. In fact, the long-term and committed process of helping the land to renew itself through conservation, ecological restoration, and environmentally sensitive development is vital. Through ecological restoration we can strive to create living natural systems that respond to the current socioeconomic contexts in which we work, live, and experience nature.

Landscape architects can play a very important role in ecological restoration and restoration design. Nevertheless, planners/designers must remember that the integration of science into restoration designs is essential if such projects are to be successful over the long term, and if we are to really learn from our ecological restoration efforts.

Effective collaboration between planners/designers and other experts and stakeholders is essential in all aspects of landscape architectural practice, particularly if we are to successfully address goals and objectives related to ecological, stakeholder, and learning success for the ecosystems we attempt to restore. As landscape architects work with land managers, ecologists, and other scientists, they must remember that the mindset of the ecological restoration practitioner is focused on following a set of protocols that will determine a design in order to make it similar to a naturally occurring ecosystem. On the other hand, landscape architects frequently desire to create an elegant or distinctive design—one that will be noticed and appreciated.

Thus, while landscape architects frequently place great emphasis on project "originality and distinctiveness," practitioners of ecological restoration seek conformity to closely observed and scientifically understood natural conditions. As shown through the work of a number of ecological restoration designers (for example, landscape architects at Andropogon, Biohabitats, Conservation Design Forum, EDAW, the National Park Service, and many other offices), these two mindsets can be successfully combined. (For selected project examples refer to Appendix A.)

"Ecological restoration designers" are more constrained in the choices they make because they design to emulate natural conditions so as to achieve functional ecosystems that are "ecologically sound" and help combat "ecological disequilibrium"

(Cairns 2006, 53–54)—as opposed to focusing primarily on creating distinctive places that inspire and accommodate human needs (the approach taken by perhaps the majority of landscape architects).

Because learning from past projects is an essential part of ecological restoration project work, we encourage all planners and designers to carefully document their project goals, procedures, and outcomes. Honestly sharing both successes and failures will make it possible to improve on collective restoration efforts and thus to more effectively heal the earth and its life-sustaining ecosystems.

We argue that the restoration of ecological systems can help renew natural capital, provide meaningful work, spur new technologies, and forge new alliances among disciplines and people. How planners and designers creatively explore these issues with other disciplines and local stakeholders will say much about our ability to both conserve and create sustainable, regenerative, and enjoyable landscapes, communities, and ecosystems to visit and learn from.

Reconnecting urban residents with ecosystems through the process of ecological restoration project work is a worthy goal, especially when coupled with the use of sound ecological practices. As such, landscape architects should consider ways to adapt the principles discussed in this paper to all project efforts.

References and Resources

References and Citations (includes references noted in the Appendices)

Allison, S.K. 2002. "When is a restoration successful? Results from a 45-year-old tallgrass prairie restoration." *Ecological Restoration* 20(1):10–17.

Apostol, D., and M. Sinclair. 2006. *Restoring the Pacific Northwest: The art and science of ecological restoration in Cascadia.* Washington, DC: Island Press.

Bainbridge, D.A. 2007. *A guide for desert and dryland restoration: New hope for arid lands.* Washington, DC: Island Press.

Barro, S.C., and A.D. Bright. 1998. "Public views on ecological restoration: a snapshot from the Chicago area." *Restoration & Management Notes* 16(1):59–65.

Bernhardt, E.S., M.A. Palmer, J.D. Allan, G. Alexander, K. Barnes, S. Brooks, J. Carr, S. Clayton, C. Dahm, J. Follsted-Shah, D. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, S. Katz, G.M. Kondolf, P.S. Lake, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, B. Powell, and E. Sudduth. 2005. "Synthesizing U.S. river restoration efforts." *Science* 308:636–637.

Bohnen, J.L., and S.M. Galatowitsch. 2005. "Spring Peeper Meadow: Revegetation practices in a seasonal wetland restoration." *Ecological Restoration* 23(3):172–181.

Bowers, K. 2006a. "Blurring the boundaries." *Ecological Restoration* 24(1):4–4.

Bowers, K. 2006b. "Human systems." *Ecological Restoration* 24(2):70–70.

Bradshaw, A.D. 1987. "Restoration: an acid test for ecology." In *Restoration ecology: a synthetic approach to ecological research*. ed. W.R. Jordan III, M.E. Gilpin, and J.D. Aber. 23–29. Cambridge: Cambridge University Press.

Bradshaw, A.D. 1997. "What do we mean by restoration?" in *Restoration ecology and sustainable development.* ed. K.M. Urbanska, N.R. Webb, and P.J. Edwards. 8–14. Cambridge: Cambridge University Press.

Bunting, S.C., J.L. Kingery, and M.A. Schroeder. 2003. "Assessing the restoration potential of altered rangeland ecosystems in the Interior Columbia Basin." *Ecological Restoration* 21(2):77–86.

Cairns, J. Jr. 1993. "Ecological restoration: replenishing our national and global ecological capital." *Nature conservation: Reconstruction of fragmented ecosystems*. ed. D.A. Saunders, R.J. Hobbs, and P. Ehrlich. 193–208. Surrey Berry & Sons.

Cairns, J. Jr., ed. 1995. *Rehabilitating damaged landscapes, 2nd Edition.* Boca Raton, FL: CRC Press.

Cairns, J. Jr. 1999. "Ecological restoration: a major component of sustainable use of the planet." *Renewable Resources Journal* 17(1):6–11.

Cairns, J. Jr. 2006. "Restoring damaged aquatic ecosystems." *Journal of Social, Political and Economic Studies* 31(1):53–74.

Chambers, J.C., and J.R. Miller, eds. 2004. *Great basin riparian ecosystems: Ecological restoration and management.* Washington, DC: Island Press.

Clewell, A.F. 2000. "Restoring for natural authenticity." *Ecological Restoration* 18(4):216–217.

Clewell, A.F., and J. Aronson. 2007. *Ecological restoration: principles, values, and structure of an emerging profession.* Washington, DC: Island Press.

Clewell, A., J. Rieger, and J. Munro. 2000/2005. *Society for Ecological Restoration International: guidelines for developing and managing ecological restoration projects*. Tucson, AZ: Society for Ecological Restoration International.

Clewell, A.F., and R. Lea. 1990. "Creation and restoration of forested wetland vegetation in the southeastern United States." *Wetland creation and restoration: The status of the science.* ed. A. Kusler and M.E. Kentula. Washington, DC: Island Press.

Clewell, A., and J.P. Rieger. 1997. "What practitioners need from restoration ecologists." *Restoration Ecology* 15(4):350–354.

Cramer, V.A., and R.J. Hobbs, eds. 2007. *Old fields: Dynamics and restoration of abandoned farmland.* Washington, DC: Island Press.

Cranz, G., and M. Boland. 2004. "Defining the sustainable park: A fifth model for urban parks." *Landscape Journal* 23(2):102–120.

Cunningham, S. 2002. *The restoration economy*. San Francisco: Berrett-Koehler.

Curtis, J.T., and H.C. Greene. 1949. "A study of relic Wisconsin prairies by the species-presence method." *Ecology* 30:83-92.

Dahl, B.E., F. Phillips, and L.R. Skabelund. 2002. "Principles for Ecological Restoration." *Proceedings of the 2002 ASLA Annual Meeting.* Washington DC: American Society of Landscape Architects (ASLA).

D'Antonio, C., and L.A. Meyerson. 2002. "Exotic plant species as problems and solutions in ecological restoration: A synthesis." *Restoration Ecology* 10(4):703–713.

Davy, T., and M. Perrow. 2002. *Handbook of ecological restoration: Volume 1, principles of restoration.* Cambridge: Cambridge University Press.

Denison, D.L. 2000. "Crosswinds Marsh Wetland Mitigation". *Land and Water*. Nov./Dec. 2000.

Denison, D.L. 2003. "Oden Creek restoration—bringing together people and trout." *Land and Water*. Sep./Oct. 2003.

Dramstad, W.E., J.D. Olson, and R.T.T. Forman. 1996. *Landscape ecology principles in landscape architecture and land-use planning*. Washington, DC: Island Press.

Eagan, S., P. Newman, S. Fritzke, and L. Johnson. 2004. "Subalpine meadow restoration in Yosemite National Park." *Ecological Restoration* 22(1):24–29.

Egan, D., and E.A. Howell. 2001/2005. *Historical ecological restoration handbook: A restorationist's guide to reference ecosystems.* Washington DC: Island Press.

Ehrenfield, J.G. 2000. "Defining the limits of restoration: The need for realistic goals." *Restoration Ecology* 8(1):2–9.

Falk, D.A., Palmer, M.A., and J.B. Zedler. 2006. *Foundations of Restoration ecology: The science and practice of ecological restoration.* Washington DC: Island Press.

Fogerty, J. 2001/2005. "Oral history: A guide to its creation and use." *Historical Ecological restoration handbook: a restorationist's guide to reference ecosystems.* ed. D. Egan and E.A. Howell, Washington DC: Island Press.

Folke, C. 2004. "Traditional knowledge in social–ecological systems." *Ecology and Society* 9(3):7.

France, R., ed. 2006. "Ethics and Ecological Restoration". *Healing nature, repairing relationships: Landscape architecture and the restoration of ecological spaces.* Cambridge, MA: The MIT Press.

Franklin, C. 1997. "Fostering Living Landscapes." *Ecological design and planning.* ed. G.F. Thompson and F.R. Steiner. New York: John Wiley & Sons.

Franklin, C. 1999. "Designing as if the earth really matters." *1999 ASLA/LAF Summit White Papers.* Washington DC: Landscape Architecture Foundation and ASLA.

Friederici. P., ed. 2003. *Ecological restoration of southwestern Ponderosa pine forests.* Washington, DC: Island Press.

Galatowitsch, S.M. 1998. "Ecological design for environmental problem solving." *Special issue, Landscape Journal, Eco-Revelatory Design: Nature Constructed/Nature Revealed.* 99–107. Madison, WI: Council of Educators in Landscape Architecture and University of Wisconsin Press.

Galatowitsch, S.M., and A.G. van der Valk. 1994. *Restoring prairie wetlands.* Ames, Iowa: Iowa State University Press.

Garbisch, E. 2005. "Hambleton Island restoration: Environmental Concern's first wetland creation project." *Ecological Engineering* 24(4):289–307.

Gobster, P.H., and R.B. Hull, eds. 2002. *Restoring nature: Perspectives from the social sciences and humanities.* Washington, DC: Island Press.

Goldenberg, N. 1999. "Philadelphia launches major restoration initiative in park system." *Ecological Restoration.* 17 (1 & 2): 8-14.

Grese, R.E. 1992. *Jens Jensen: Maker of natural parks and gardens.* Baltimore, MD: Johns Hopkins University Press.

Grese, R.E., R. Kaplan, R.L. Ryan, and J. Buxton. 2000. "Psychological benefits of volunteering in stewardship programs." *Restoring nature: Perspectives from the social sciences and humanities.* Washington, DC: Island Press.

Hawken, P. 2007. "To remake the world: Something earth-changing is afoot among civil society." *Orion: Nature/Culture/Place.* May/June 2007:60–63.

Higgs, E. 2003. *Nature by design: People, natural process, and ecological restoration.* Cambridge, MA: The MIT Press.

Holloran, P. 1996. "The greening of the Golden Gate: community-based restoration at the Presidio of San Francisco." *Restoration & Management Notes* 14(2):112–123.

Hough, M. 1990. *Out of Place: Restoring Identity to the Regional Landscape.* New Haven, CN: Yale University Press.

Johnson, C.W., et al. 1999. *Conservation corridor planning at the landscape level: Managing for wildlife habitat.* Washington, DC: USDA-NRCS Watershed Science Institute & Wildlife Habitat Management Institute.

Johnson, R., and D. Gjerstad. 1998. "Landscape-scale restoration of the longleaf pine ecosystem." *Restoration & Management Notes* 16(1):41–45.

Jordan, W.R. 2003. *The sunflower forest: Ecological restoration and the new communion with nature.* Berkeley: University of California Press.

Jordan, W.R., Gilpin, M.E. and J.D. Aber, ed. 1987. *Restoration ecology: A synthetic approach to ecological research.* Cambridge: Cambridge University Press.

Kaplan, R., Kaplan, S., and Ryan, R.L. 1998. *With people in mind: Design and management of everyday nature.* Washington, DC: Island.

Kern, K. 1992. "Restoration of lowland rivers: The German experience." In *Lowland floodplain rivers: Geomorphological perspectives,* ed. P.A. Carling and G.E. Petts, Chichester: Wiley. 279–297.

Kondolf, G.M. 1998. "Lessons learned from river restoration projects in California." *Aquatic Conservation: Marine and Freshwater Ecosystems.* 8(1):39–52.

Kondolf, G.M., and M. Larson. 1995. "Historical channel analysis and its application to riparian and aquatic habitat restoration." *Aquatic Conservatio*n 5:109–126.

Kondolf, G.M., M.W. Smeltzer, and S. Railsback. 2001. "Design and performance of a channel reconstruction project in a coastal California gravel-bed stream." *Environmental Management* 28:761–776.

Kusler, J.A., and M.E. Kentula. 1990. "Executive summary." *Wetland creation and restoration: The status of the science*. ed. J.A. Kusler and M.E. Kentula. Washington, DC: Island Press.

Kush, J.S., R.S. Meldahl, and C. Avery. 2004. "A restoration success: Longleaf pine seedlings established in a fire-suppressed, old-growth stand." *Ecological Restoration* 22(1):6–10.

Lambert, A. 1999. "Shifting paradigms: The heart of education in restoration education." *Ecological Restoration* 17(3):126–135.

Lane, C., and S. Raab. 2002. "Great River greening: A case study in urban woodland restoration." *Ecological Restoration* 20(4):243–251.

Lindig-Cisneros, R., and J.B. Zedler. 2000. "Restoring urban habitats: A comparison of three projects provides clues to better results." *Ecological Restoration* 18(3):184–192.

MacMahon, J.A., and K.D. Holl. 2001. "Ecological restoration: A key to conservation biology's future." *Conservation biology: Research priorities for the next decade.* ed. M.E. Soule and G.H. Orians. Washington, DC: Island Press.

MacMahon, J.A., and W.R. Jordan. 1994. "Ecological Restoration." *In Principles of conservation biology*. ed. Meffe, G.K., C.R. Carroll, and contributors, 409–438. Sunderland, MA: Sinauer Associates, Inc.

Marzluff, J.M., and K. Ewing. 2001. "Restoration of fragmented landscapes for the conservation of birds: A general framework and specific recommendations for urbanizing landscapes." *Restoration Ecology* 9(3):80–292.

Masters, L.A. 1997. "Monitoring vegetation." *The tallgrass restoration handbook: For prairies, savannas, and woodlands.* ed. S. Packard and C.F. Mutel. Washington, DC: Island Press.

May, S. 2001. "Management of invasive species in restoration projects." *Land and Water*. July/Aug. 2001.

McCarty, K. 1998. "Landscape-scale restoration in Missouri savannas and woodlands." *Restoration & Management Notes.* 16(1):22–32.

Mitsch, W.J. and S.E. Jørgensen. 2004. *Ecological engineering and ecosystem restoration*. Hoboken, NJ: John Wiley & Sons.

Nassauer, J.I., ed. 1997. *Placing nature: Culture and landscape ecology.* Washington, DC: Island Press.

National Research Council. 1992. *Restoration of aquatic ecosystems*. Washington, DC: National Academy Press.

National Research Council. 2002. *NEON: Assessing the nation's environmental challenges.* Washington, DC: National Academies Press.

Noss, R.F. and A.Y. Cooperrider. 1994. *Saving nature's legacy.* Washington, DC: Island Press.

Packard, S. 1997. "Interseeding." *The tallgrass restoration handbook: for prairies, savannas, and woodlands.* ed. S. Packard and C.F. Mutel. Washington DC: Island Press.

Palmer, M.A., E.S. Bernhardt, J.D. Allan, P.S. Lake, G. Alexander, S. Brooks, J. Carr, et al. 2005. "FORUM: Standards for ecologically successful river restoration" *Journal of Applied Ecology* 42:208–217.

Perlman, D.L. and J.C. Milder. 2005. *Practical ecology for planners, developers, and citizens.* Washington, DC: Island Press.

Purcell, A.H., C. Friedrich, and V.H. Resh. 2002. "An assessment of a small urban stream restoration project in Northern California." *Restoration Ecology* 10(4):685–694

Reed, C.C. 2004. "Keeping invasive plants out of restorations." *Ecological Restoration* 22(3):210–216.

Rich, T. 2002. "Using breeding land birds in the assessment of western riparian systems." *Wildlife Society Bulletin* 30(4):1128–1139.

Riley, A.L. 1998. *Restoring streams in cities: a guide for planners, policy makers, and citizens.* Washington, DC: Island Press.

Rochefort, R.M., and S.T. Gibbons. 1992. "Mending the meadow: high-altitude meadow restoration in Mount Rainier National Park." *Restoration & Management Notes* 10(2):120–126.

Royal Commission on the Future of the Toronto Waterfront (RCFTW). 1992. *Regeneration: Toronto's waterfront and the sustainable city: Final report.* Minister of Supply and Services Canada.

Ryan, R.L. 2002. "Exploring landscape architects' attitudes toward ecological restoration and remediation." In *CELA 2002: Council of Educators in Landscape Architecture Annual Conference.* SUNY College of Environmental Science and Forestry, Syracuse, NY. September 25–28, p. 187–188.

Sauer, L. and Andropogon Associates. 1998. *The once and future forest: a guide to forest restoration strategies*. Washington, DC: Island Press.

Schramm, P. 1992. "Prairie restoration: A twenty-five year perspective on establishment and management." In *Proceedings of the Twelfth North American Prairie Conference: Recapturing a vanishing heritage,* ed. D.D. Smith and C.A. Jacobs. Cedar Falls: University of Northern Iowa Press.

SER (Society for Ecological Restoration International), Science & Policy Working Group. 2002/2004.

The SER international primer on ecological restoration. Tucson, AZ.

Shepp, D.I., and J.D.Cummins. 1997. "Restoration in an urban watershed: Anacostia River of Maryland and the District of Columbia." *Watershed Restoration: Principles and Practices*. ed. J.E. Williams, C.A. Wood, and M.P. Dombeck. Bethesda, MD: American Fisheries Society.

Simberloff, D. 2003. "Eradication—preventing invasions at the outset." *Weed Science*. 51:247–53.

Simmons, M.T., Venhaus, H.C., and S. Windhager. 2007. "Exploiting the attributes of regional ecosystems for landscape design: the role of ecological restoration in ecological engineering." *Ecological Engineering* 30(3):201–205.

Swink, F.S., and G.S. Wilhelm. 1994. *Plants of the Chicago region.* Indianapolis, IN: Academy of Science.

Tamminga, K.R. 1997. "Restoration planning in the urbanizing (bio) region: Ecological themes and regional perspectives." *Proceedings from Opportunities in Sustainable Development: Strategies for the Chesapeake Bay.* ed. M. Hill. 67–75. Washington DC: ASLA.

Temperton, V.M., R.J. Hobbs, T. Nuttle, and S. Halle. 2004. A*ssembly rules and restoration ecology: Bridging the gap between theory and practice.* Washington DC: Island Press.

Throop, W. 2001. "Restoring nature: balancing nature and humans in ecological restoration." *Ecological Restoration.* 19(4):215–217.

Toth, L.A., D.A. Arrington, and G.Begue 1997. "Headwater restoration and reestablishment of natural flow regimes: Kissimmee River of Florida." *Watershed restoration: principles and practices.* ed. J.E. Williams, C.A. Wood, and M.P. Dombeck. Bethesda, MD: American Fisheries Society.

van Diggelen, R., A.P. Grootjans, and J.A. Harris. 2001. "Ecological restoration: State of the art or state of the science?" *Restoration Ecology* 9(2):115–118.

Whisenant, S.G. 1999. *Repairing damaged wildlands: A process-oriented, landscape scale approach.* Cambridge: Cambridge University Press.

Zedler, J.B. 2000. "Progress in wetland restoration ecology." *Trends in Ecology & Evolution* 15:402–07.

Recommended Books (selected references on ecological restoration and ecology)

Documents and books listed on the SER International website (*www.ser.org/reading_resources.asp*) are of particular interest to those desiring to learn more about ecological restoration and the science of restoration ecology. Below are a few examples:

The SER International Primer on Ecological Restoration (2004)
http://www.ser.org/pdf/primer3.pdf

Natural Capital and Ecological Restoration (2004)
http://www.ser.org/content/Naturalcapital.asp

Guidelines for Developing and Managing Ecological Restoration Projects (2005)
http://www.ser.org/content/guidelines_ecological_restoration.asp

Global Rational for Ecological Restoration (2006)
http://www.ser.org/content/Globalrationale.asp

Restoring Natural Capital: Science, Business and Practice
http://www.ser.org/content/restoring_natural_capital.asp

The Historical Ecology Handbook by Egan and Howell (2001) discusses the selection restoration targets. This book was re-published in 2005.

Assembly Rules & Restoration Ecology by Temperton et al. (2004) contributes to the understanding of how ecosystems are assembled and function and how they can be restored.

Foundations of Restoration Ecology: The Science and Practice of Ecological Restoration, edited by Falk, Palmer, and Zedler (2006), connects restoration practice with ecological theory.

Ecological Restoration: Principles, Values, and Structure of an Emerging Profession by Clewell and Aronson (2007) builds on SER's ecological restoration guidelines.

Books on ecology and the restoration of specific types of ecosystems are now quite abundant. Below are a few noteworthy examples that are particularly relevant to the types of projects and ecosystems landscape architects are commonly involved with.

Landscape Ecology Principles in Landscape Architecture and Land Use Planning (Dramstad, Olson, and Forman 1996) provides an excellent overview of key ideas from the fields of ecology and landscape ecology, with particular attention to the relationship between landscape structure and its dynamic functions or processes.

Practical Ecology for Planners, Developers, and Citizens (Perlman and Milder 2005) introduces ecological principles to non-scientists and includes a chapter on restoration.

The Tallgrass Restoration Handbook (Packard and Mutel 1997) provides excellent insights on restoring prairies, savannas, and woodlands.

The Once and Future Forest (Sauer 1998) offers guidance for restoring forests, woodlands, stream corridors, and meadows in urban settings.

Stream Corridor Restoration: Principles, Processes, and Practices
http://www.nrcs.usda.gov/technical/stream_restoration/newtofc.htm

An Introduction to Wetland Restoration, Creation, and Enhancement
http://www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Selected Websites

ASLA's Reclamation & Restoration Professional Practice Network provides ASLA members with the opportunity to exchange ideas about land reclamation and ecological restoration activities with other professionals and academics.
www.asla.org/reclamation

SER seeks to broaden and deepen the sharing of "restoration lessons learned" via the SER Internet site (in particular, refer to the "Restoration Project Showcase"), the Global Restoration Network (GRN), and journal articles in Ecological Restoration and Restoration Ecology.

SER
www.ser.org

GNR
www.globalrestorationnetwork.org/

Ecological Restoration Journal
http://www.ecologicalrestoration.info/backissues.asp

Restoration Ecology Journal
http://www.blackwellpublishing.com/journal.asp?ref=1061-2971

NRRSS—National River Restoration Science Synthesis
http://www.restoringrivers.org/

USEPA—Principles for the Ecological Restoration of Aquatic Resources
http://www.epa.gov/owow/wetlands/restore/principles.html

USEPA—Rapid Biological Assessment Protocols
www.epa.gov/owowwtr1/monitoring/rbp/app_a.html

St. Louis Declaration—"Voluntary Codes of Conduct to Prevent Plant Invasions" (codes for landscape architects and other professionals)
www.centerforplantconservation.org/invasives/codesN.html

Invasive Species Management
http://www.invasivespecies.gov/

USDA, NRCS—*The PLANTS Database*
http://plants.usda.gov

Appendix A: Learning from Ecological Restoration Projects in North America

Articles, books, and websites highlight a number of examples of ecological restoration project work in various landscape and ecosystem contexts across the United States. Given that there are thousands of restoration projects to choose from, the intent of these examples is to provide a glimpse into the range of work that planners and designers could potentially be involved with.

Ecological Restoration Case Studies (project examples)

Stream and Riparian Corridor Restoration
River and stream restoration have been among the most popular types of ecological restoration efforts nationwide, with a particularly high concentration of projects on the Pacific Coast and in the Chesapeake Bay region. To get an overview of recent trends in river restoration, consult the webpage for the National River Restoration Science Synthesis study: *http://www.restoringrivers.org/*. Restoring flowing rivers is particularly challenging, given that many river systems are naturally characterized by very dynamic behavior in response to high flows and fluctuations in sediment transport. Uncertainty is high for many projects. Each river restoration project should be treated as an experiment, through which we can better understand the system response and thereby improve future project performance. Unfortunately, this is rarely done. However, systematic post-project appraisals of completed restoration projects are now being undertaken in California (*http://lib.berkeley.edu/WRCA/restoration/*), Colorado (*http://co.water.usgs.gov/projects/rcmap/*), and North Carolina (by Western Carolina University faculty and students).

An excellent summary of physical and ecological principles in stream restoration is available in the Federal Interagency "Stream Corridor Restoration" manual (*http://www.nrcs.usda.gov/technical/stream_restoration/*). Bernhardt, et al. (2005) and Johnson (1999) discuss corridor restoration and river restoration efforts in the U.S.

Some example projects, at different scales, are presented at the following websites:
http://www.evergladesplan.org/about/landing_about.cfm

Great Basin & Provo River Restoration, UT (Chambers & Miller 2004)
http://www.mitigationcommission.gov/prrp/prrp.html; *http://utahoutdoors.com/pages/provorebuild.htm*

Baxter Creek Daylighting, El Cerrito, CA
http://www.urbancreeks.org/Current_Projects.html

Nine Mile Run, Pittsburgh, PA
http://www.ninemilerun.org/Watershed/restoration/index.htm

Coffee Creek Restoration, Chesterton, IN
http://www.coffeecreekwc.org/pages/restoration.htm

Oden Creek, MI (Denison 2003)
http://www.jjr-us.com/JJRNaturalResources/Content/Projects/Project.asp?pn=154&pt=1

Coastal and Freshwater Wetland Restoration and Reclamation

(Kusler & Kentula 1990; Zedler 2000)
http://www.epa.gov/owow/wetlands/restore/finalinfo.html
http://www.epa.gov/owow/wetlands/restore/links/

Prairie Wetland Restoration (Galatowitsch and van der Valk 1994; Bohnen and Galatowitsch 2005)
Des Plaines River Restoration Project, IL
http://www.wetlands-initiative.org/
The Hennepin & Hopper Lakes Project is a large-scale restoration effort in the Upper Mississippi River Basin
http://www.wetlands-initiative.org/HennHopper.html

Crosswinds Marsh, Wayne County, MI (Denison 2000; *Landscape Architecture Magazine*, July 2000, "Where the Runway Ends")

Louisiana Wetlands Restoration Plan
http://lacoast.gov/reports/program/index.asp
CWPPRA Restoration Projects
http://www.lacoast.gov/projects/list.asp

San Francisco Bay, Delta, CA (Holloran 1996)
http://calwater.ca.gov/index.aspx
Hill Slough West & Crissy Field projects, San Francisco—marsh restoration are key parts of each design.
http://calwater.ca.gov/performancetracking/project_performance.html
http://www.asla.org/meetings/awards/awds02/crissyfield.html

Tidal & Freshwater Wetlands in the Pacific Northwest (Apostol and Sinclair 2006)

Salt Marsh Restoration, CT
http://environment.yale.edu/doc/807/restoration_of_an_urban_salt_marsh/

Bottomland Hardwood Forest Restoration/Management
Southeastern Forested Wetland Creation & Restoration (Clewell and Lea 1990)
Southern Longleaf Pine Restoration (Johnson and Gjerstad 1998; Kush et al. 2004)
http://www.fws.gov/southeast/partners/pfwpine.html

Pinecote, Crosby Arboretum, Picayune, MS (Franklin 1997)
http://www.crosbyarboretum.msstate.edu/index.php

Pacific Northwest and Great Basin Forest Restoration
Old Growth Conifer Forests & Oak Woodlands in Cascadia (Apostol and Sinclair 2006)

Ponderosa Pine Forest Restoration/Management (Friederici 2003)

Temperate Forest/Woodland Restoration/Management
Great River Greening, Twin Cities, MN (Lane and Raab 2002)
http://www.greatrivergreening.org/)

Chicago Wilderness Restoration/Management (Gobster and Hull 2002)
http://www.chicagowilderness.org/index.php
Savanna & Woodland Restoration (McCarty 1998)
http://www.northbranchrestoration.org/

Central Park Woodlands Management. New York City, NY (Franklin 1997; Sauer 1998)
http://www.amnh.org/science/biodiversity/extinction/Day2/bytes/CramerPres.html

Fairmont Park Forest Management, Philadelphia, PA (Goldenberg 1999)
http://www.fairmountpark.org/EnvironmentalRestoration.asp

Avalon Park and Preserve, Long Island, NY (Andropogon Associates)
http://www.andropogon.com/

Prairie and Savanna Restoration/Management (Packard and Mutel 1997; Cramer & Hobbs 2007)
Great Plains Restoration Initiative
http://www.gprc.org/millionacreproject.html
The Great Plains Restoration Council proposed a million-acre core reserve of prairie based on ideas discussed by Noss and Cooperrider (1994). This "Million Acre Project" is envisioned to restore and protect a "prairie safe zone."

Midewin National Tallgrass Prairie restoration/management
http://www.fs.fed.us/mntp/plan/index.htm)

Curtis Prairie, Madison, WI (Curtis & Greene 1949; Schramm 1992)
http://uwarboretum.org/about/communities_collections/

Green Oaks Prairie, West-Central Illinois (Allison 2002)
http://www.knox.edu/x2024.xml – "How to Guide")

MWRDGC Natural Landscape Assessment & Restoration, Chicago, IL (Conservation Design Forum)
http://www.cdfinc.com

Arid Lands Restoration (Whisenant 1999; Bainbridge 2007)
Shrub-Steppe Restoration, Intermountain West (Apostol and Sinclair 2006; Bunting et al. 2003)
http://www.kettlerange.org/steppeweb/
http://wdfw.wa.gov/science/rsrch_briefs/shrub_step.html

Rock Canyon Re-vegetation, Provo, UT (Phil Allen – BYU-Horticulture Dept.)
http://centerforservice.byu.edu/content/view/4665/

High Elevation Meadow Restoration
Mount Ranier National Park (Rochefort and Gibbons 1992)

High Elevation Restoration at Glacier and Yellowstone National Parks
http://www.mt.nrcs.usda.gov/technical/ecs/plants/pmpubs/highelnative.html

Yosemite National Park (Eagan et al. 2004)
http://www.yosemite.org/helpus/volunteer.html

Regional & Urban Restoration (Hough 1990; RCFTW 1992; Tamminga 1997; Shepp and Cummins 1997; Riley 1998; Lindig and Zedler. 2000; Marzluff and Ewing. 2001; Purcell et al. 2002; Simmons et al. 2007)

Appendix B: Implementing Ecological Restoration Within the Planning/Design Framework

Over the past 10 years, the Society for Ecological Restoration International (SER) has developed an extensive set of guidelines related to planning and implementing ecological restoration projects. In their most recent set of guidelines, Clewell, Rieger and Monro (2000/2005) discuss 51 guidelines (refer to *http://www.ser.org/pdf/SER_International_Guidelines.pdf* or Clewell and Aronson 2007).

Guidelines for Ecological Restoration Projects

The guidelines presented by Clewell and his co-authors help planners, designers, and other team members think through the many variables related to organizing, designing, implementing, and assessing ecological restoration projects. In short, they serve as an important reference for planners, designers, and others considering or participating in ecological restoration work.

The authors indicate that adhering to their proposed guidelines will reduce errors of omission and commission that may compromise project quality, and that the guidelines are applicable to all ecosystems. As such, the guidelines are "useful in any context—public works projects, stewardship programs, mitigation projects, private land initiatives, etc." and provide "essential background for managers, policy makers, and the interested public as well as for professional and volunteer restoration practitioners" (Clewell, Rieger, and Munro 2000, Intro.).

The ecological restoration guidelines outlined in this appendix address:

- undertaking pre-restoration monitoring, inventory, and analysis for scientific understanding;
- addressing social issues and developing meaningful restoration goals;
- documenting how to implement restoration projects;
- implementing initial restoration and management tasks;
- monitoring, maintaining, and employing adaptive management to restored ecosystems; and
- implementing long-term project monitoring, evaluation, and publicity activities.

Specific design strategies, construction details, and project specifications (which may be needed for implementing many of the restoration efforts planners/designers are involved with) lie beyond the scope of this paper and must be generated based upon the unique attributes of each project and place (site, ecosystems, and larger landscape context).

Initial Project Tasks—Pre-Monitoring and Inventory/Analysis for Scientific Understanding

Initial project tasks include identifying the need for ecological restoration via pre-monitoring and/or initial inventory and analysis efforts. Per Clewell, Rieger, and Munro (2000/2005), there are more than a dozen important tasks in the initial stages of project planning. These are summarized below.

Through initial project tasks the project team first identifies important site and landscape changes and specifically determines why ecological restoration is needed. This can be done as we prepare site inventories and monitor site systems, learn from previously completed inventories and studies, talk to knowledgeable informants, and examine related environmental assessments.

Understanding the causes of degradation (including missing components and undesirable additions), as well as the appropriate boundaries and scale of the proposed restoration effort, will help a project team chart a path toward sound ecological restoration (Perlman and Milder 2005).

Once the vital step of determining the causes of ecosystem degradation is completed, 12 additional tasks should be undertaken to identify:
1. the kind of system to be restored;
2. restoration goals related to ecological, social, and cultural values;
3. the specific physical conditions in need of repair;
4. natural and cultural disturbances or other stressors in need of management, regulation, or restortion;
5. the kinds of biotic interventions needed;
6. past or present landscape restrictions or limitations (larger-scale contextual issues);
7. project funding sources;
8. sources of skilled and volunteer labor and equipment needs;
9. biotic resource needs and sources of seeds, propagules, plants, soils/soil fauna, and other resources;
10. permitting requirements, deed restrictions, and other legal constraints;
11. the duration of the project and whether long-term "hands-on" management is anticipated; and
12. strategies for long-term protection, use, and management.

Conceptual Planning—Addressing Social Issues and Developing Meaningful Goals

Setting realistic goals is vital to the effective practice of ecological restoration.

This idea relates directly to Clewell, Rieger, and Munro's (2000/2005) discussion about identifying the type of project to undertake and then identifying specific restoration goals. Closely linked are the set of issues described under their heading "Conceptual Planning," which they say "should be conducted when restoration appears to be feasible but before a decision has been made to exercise that option. The written conceptual plan captures the essence and character of the potential restoration."

Clewell, Rieger, and Munro (2000/2005) describe 17 "preliminary tasks" as forming the foundation for well-conceived ecological restoration designs and programs. Preliminary tasks are undertaken after conceptual planning and following the decision to proceed with the ecological restoration project. Obviously these tasks may be done in an order different than listed below.

During conceptual planning, the project team:
1. appoints a restoration practitioner or other qualified individual to be in charge of all technical apects of ecological estoration for a project;
2. appoints the restoration team;
3. prepares a budget to accommodate the completion of preliminary tasks;
4. documents the history of the project site so as to reveal the need for restoration;
5. documents existing site conditions and describes the biota;
6. conducts pre-project monitoring as needed to support project objectives;
7. establishes a reference upon which the ecological restoration effort will be modeled and evaluated;

8. gathers pertinent autoecological (behavioral) information for key species;
9. conducts investigations as needed to assess the effectiveness of ecological restoration methods;
10. decides whether ecosystem goals are realistic or whether they need modification;
11. prepares a list of objectives designed to achieve restoration goals;
12. secures permits required by regulatory and zoning authorities;
13. establishes liaisons with interested governmental agencies;
14. establishes trust with the public and publicizes the project;
15. arranges for public participation in project planning and implementation to fulfill sociocultural goals;
16. oversees the installation of roads, trails, and/or other infrastructure needed to facilitate project implementation; and
17. engages and trains the personnel who will supervise and conduct project implementation tasks.

Planning and Design—Documenting How to Implement the Project

Per Clewell, Rieger, and Munro (2000/2005): "Installation or Implementation Plans" describe how the project is to be implemented, or in other words, how the project is designed, installed, and managed over time. The authors note that "the care and thoroughness with which installation planning is conducted will be reflected by how aptly project objectives are executed."

During the detailed planning/design phase, the project team
1. describes the interventions that will be implemented to attain each objective;
2. acknowledges the role of passive restoration by estimating how much of the restoration can be accomplished via natural processes[1;]
3. prepares performance standards and monitoring protocols to measure the attainment of each objective;
4. schedules the tasks needed to fulfill each objective;
5. obtains appropriate equipment, supplies, and biotic resources for the required tasks; and
6. prepares a budget for implementation tasks, maintenance events, and contingencies.

Implementing Initial Restoration and Management Work

Per Clewell, Rieger, and Munro (2000/2005) "Project Implementation" fulfills the intentions described by earlier plans and specifications. The authors indicate that if planning is thorough and supervision adequate, implementation will generally proceed smoothly and within budget. Geist and Galatowitsch (1999) note that ecological restoration failures typically occur due to cost constraints, limitations in land allocation, insufficient time and labor, and underlying obstacles related to human attitudes and behaviors. Thus, as previously discussed, training and effective stakeholder involvement are critical aspects of implementation, and local community members can assist with many tasks.

1 According to Clewell, Rieger & Munro (2001/2005), passive ecological restoration means allowing natural forces to both initiate and drive vegetative succession on a project site. If a correction to the physical environment is all that is needed to initiate the recovery of the biota, then the practitioner can limit restoration activities to making that correction. Passive restoration may be essential when a site simply does not need to be planted or when funding does not allow for substantial planting/seeding. Given their prevalence in urbanizing contexts, in almost all instances invasive species will need to be managed, and this could be the sole or primary focus of an ecological restoration project.

As implementation is undertaken the project team ensures that the following tasks are accomplished in accordance with earlier plans/designs and agreed upon project changes:

1. Boundaries are marked and the project area secured for safety and protection;
2. Permanent monitoring features are typically installed in order to assess the effectiveness of ecological restoration activities;
3. Restoration and management tasks are implemented per plans (which likely include detailed design work and construction documents) and necessary field changes.

Post-Implementation—Monitoring, Maintenance, and Adaptive Management

According to Galatowitsch (1998), ecological designs cannot be considered successful without appraising biological changes that occur following implementation. Correspondingly, planners and designers of ecological restoration projects need to answer the following question: Should current restoration and management practices be continued or modified? Masters suggests that "the best way to answer this question is by monitoring the changes that happen during restoration" (1997, 279). During the planning process, restoration planners/designers need to develop monitoring programs with clear objectives and answerable questions, explicitly state what "restoration success" means, determine the "indicators of ecosystem change," and describe how these changes will be measured (Masters 1997).[2]

Per Clewell, Rieger, and Munro (2000/2005), "The attainment of [project] objectives may depend as much on aftercare [and related follow-up activities] as it does to the care given to the execution of implementation tasks." Thus, the importance of post-implementation work cannot be overemphasized.

During the post-implementation phase the project team seeks to ensure that the following steps are taken:

1. protect the project site against vandals and herbivory;
2. perform post-implementation maintenance;
3. revisit the project site regularly to identify needs for mid-course corrections;
4. perform monitoring as required to document the attainment of project goals, objectives, and performance standards;
5. implement adaptive management procedures as these are needed.

Long-Term Project Monitoring, Evaluation, and Publicity

Per Clewell, Rieger, and Munro (2000/2005), "The installation of a project does not guarantee that its objectives will be attained or its goals achieved. Restoration differs from most civil engineering projects for which the results are more predictable. Restored ecosystems are dynamic and require evaluation within the context of an indefinite temporal dimension."

---

2 One way to monitor ecosystem restoration is to measure floristic changes using quantitative sampling in sufficient numbers and intervals "to achieve a representative amount of plant frequency and coverage data" (Masters 1997, 283). Floristic quality assessments can be undertaken to measure intact structure, composition and processes (Swink & Wilhelm 1994; Masters 1997). Another technique is to monitor changes in the composition of bird species, reptiles, insects, fishes, or other animals at the restored site. Monitoring breeding riparian obligate/dependent birds can be particularly helpful in understanding the success of a restored riparian ecosystem when the stated goal is to create viable habitat for these species since many land birds depend on riparian zones for nesting/breeding (Rich 2002).

Over the long term the project team should:

1 continue monitoring programs and assess monitoring data to determine if project performance standards are being met;

2. conduct an ecological evaluation of the completed project;

3. determine if project goals were met, including those for social and cultural values; and

4. publish a written account of the completed restoration project and publicize the project.

Appendix C: Questions Reviewed by Ecological Restoration Experts —Fall 2005

After reviewing the nine points noted in the Executive Summary, restoration experts contacted for this paper were asked to answer the following questions:

1. In the context of projects where planners/designers are key players, how would you define "successful ecological restoration"? What would be the hallmarks of successful ecological restoration projects? Where planners/designers have been closely involved, are there specific projects you deem to be "very successful"? If so, why, and what/where would these be?

2. What are the major obstacles to successful ecological restoration?

3. How have you been able to overcome these obstacles?

4. What can be generalized from ecological restoration projects deemed successful or unsuccessful?

5. How helpful are SER's Guidelines for Ecological Restoration?

6. Is the public vital to the success of ecological restoration projects? What are the appropriate roles of the public/community in ecological restoration?

7. What are some principles landscape architects and other designers should know and employ related to invasive species management (as it relates to ecological restoration)?

8. What guidance can you offer related to addressing conflicting agency mandates and/or significant interdisciplinary differences?

9. What guidance can you offer related to addressing conflicting public/stakeholder interests?

Note: Key ideas and questions were prepared for distribution to 20–40 professionals working across the United States and completed on September 15, 2005. Reponses were offered by 13 individuals and/or professional firms. Similar issues and questions were also commented on by two additional reviewers, while ASLA staff members, Jennifer Strassfield and Rachel Shaw, provided comments on working drafts of the paper.