Chapter 8
Non-native Plants and Adaptive Collaborative Approaches to Ecosystem Restoration in the United States

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8.1 Introduction

Non-native invasive plant species (NNIPS) pose a serious socio-ecological challenge due to their potential to replace and damage critical human-sustaining ecosystems (OTA 1993; Mack et al. 2000; Pimentel 2002). The impacts of non-native species are widespread and significant—altering ecosystem structure and function, threatening other species, and imposing human economic and cultural costs (Mack et al. 2000; Pfeiffer and Voeks 2008). In an increasingly globalized and human-dominated world, species from different bioregions are mixing at increasing rates through the opening of new transportation and migration corridors, disturbances, and a changing environment (Hobbs et al. 2006). Most assessments agree that these unbalancing dynamics are being unleashed at rates too rapid to be countered by adjustments in existing ecosystems, and the result will be an unpredictable new array of "novel ecosystems" (MA 2005; Diamond 1999; Hobbs et al. 2006; Seastedt et al. 2008). Ecosystems everywhere are being affected, and the challenge is such that it can only be effectively responded to by new networks of collaboration and assistance that engage land owners, managers, scientists, and policy-makers.

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Invasive species, like many other global threats, cannot be directly addressed via a single global-scale effort. Solutions instead must be found through many diverse and adaptive responses—the local conservation of sustainable ecosystems by cooperating citizens and scientists supported by favorable policy and institutional environments. In this chapter, we outline a process to expand and coordinate knowledge, technologies, and human organization and effort to safeguard and restore ecosystems degraded by non-native invasive plants. We present an overview of developments underway in the United States (US) South and West as examples of efforts to establish working platforms of interconnected human knowledge networks to promote integrated learning and action to restore ecosystems threatened by invasive species.

8.2 The Dilemma of Non-native Invasive Plant Species

Non-native invasive plant species (NNIPS) have been and continue to be both accidentally and intentionally introduced (Mack et al. 2000; Pimentel 2002; Conn et al. 2008; Carrete and Tella 2008). The US borders, like those of most countries, are relatively porous to plant movement because of the increased volumes of trade, including international internet sales, and lack of policies and border surveillance resources (Simberloff et al. 2005). Most plant invaders of wildlands have gained entry to the US through the plant production industry or by other deliberate introductions, since there is little regulation on which species are imported (OTA 1993; NRC 2002). Of the 20,000 non-native plant species now free living in the US, about 4,500 have invasive tendencies, while thousands more reside in our gardens, moving with the expanding urban fringe, with unknown consequences to adjoining lands (OTA 1993; Pimentel 2002). The commerce of importing invasive plants has been addressed with appropriate prohibitions in a voluntary national code of conduct, “The St. Louis Declaration,” which unfortunately appears to be ineffectual and little heeded at this time (Randall et al. 2001).

There is a critical need for research and policy action to address many aspects of NNIPS (Simberloff et al. 2005). There is also a need to develop new management approaches that address this complex problem to avoid marked and permanent alterations of forest, agricultural, and conservation lands and waters as NNIPS spread from urban, suburban, and exurban lands and connecting right-of-ways (Liebhold et al. 1995; Simberloff 1996; NRC 2002; Von der Lippe and Kowarik 2006). Invasive plants thus represent a complex and perplexing societal dilemma, with need for a more comprehensive awareness, management strategies, coordinated programs, and effective laws if we are to avoid bequeathing future generations degraded ecosystems and ecosystem services. It has become clear that a concerted, holistic effort that integrates science with management in new ways will be required for predicting, managing, and mitigating the spread of invasive species (McPherson 2004), and that society needs to develop a new approach to this problem.

8.3 A New Approach to Non-native Invasive Plant Species: Adaptive Collaborative Restoration

Non-native invasive plant species are one example of the complex social and ecological challenges of today, which operate across oceans and continents, broad landscapes, and social institutions, and thus require new science and management approaches. Because human activities have profound impacts on natural ecosystems, policy makers and managers need to manage complex and interlinked human-dominated and natural systems, often in mosaics of different ownership and management regimes. In addition, managers and policy-makers need to respond to the way changing human populations—more people, larger urban and exurban populations, changes in values over time—alter society's expectations of desirable benefits and values from ecosystems. A complicating dilemma is that there are few, or essentially no, clear pristine or equilibrium states that can serve as desired future conditions owing to the over abundance of novel ecosystems—assemblages of species on altered landscaped that have never before coexisted (Baron et al. 2008; Botkin 1990; Hobbs et al. 2006; Minteer and Manning 2003; Seastedt et al. 2008). Effective resource management in today's world must operate on multiple scales, take uncertainty into account, be experimental in developing new techniques, and be capable of responding to change and surprise (Jannsen 2002; Bormann et al. 2007). To address these challenges, natural resource and ecosystem management has increasingly incorporated ideas from three new areas: adaptive management, governance approaches involving collaboration, and restoration ecology (Buck et al. 2001; Colfer 2005; Lee 1993; Minteer and Manning 2003; Plummer and Armitage 2007; Sauer 1998).

8.3.1 Adaptive Management

Adaptive management generally refers to a process of self-conscious learning-by-doing that incorporates formal processes of goal setting and modeling, scientific research, monitoring, and rapid incorporation of new knowledge into refined goals and models to create a cyclical process of learning, adapting, and managing (Walters 1997; Schelhas et al. 2001; Bormann et al. 2007). Scientific research is fundamental to management, but traditional methods often have several limitations. First, traditional research in replicated experimental plots must often be replaced or supplemented with new landscape-scale research methods carried out on larger land areas than are typically allocated to ecosystem experiments. Second, the usual scientific research process typically requires too much time to produce results useful to managers facing urgent problems (Seastedt et al. 2008). Managers often cannot wait for experiments to be designed, data to be collected and analyzed, and conclusions drawn before taking action. At the same time, the management actions that are taken to address urgent problems need to be carefully evaluated and refined based on their results and in light of new scientific information, or they risk repeating mistakes or misunderstanding successes. To address these issues, adaptive management links scientists and managers to communicate, review plans and outcomes, and then modify procedures accordingly.

Adaptive management has a number of important elements. First, it acknowledges that scientific information is rarely complete or sufficient for natural resource management, particularly in the case of new and rapidly changing problems and issues. Thus there is a need for both ongoing scientific research, informed by managers' experiences, to understand the complex processes of socio-natural ecosystems, and monitoring of ecosystems to establish reference conditions, identify thresholds, and monitor change (Baron et al. 2008). Second, adaptive management is a systematized process of learning-by-doing, distinguished from trial and error by its use of modeling to develop experimental management actions and by periodic reflections on the results of management action before beginning the process anew (Schelhas et al. 2001). Walters (1997) sees modeling as a critical component of adaptive management, serving three functions:

1. aiding in problem clarification and enhancing communication among scientists, managers and other stakeholders by providing a concrete reference point for wide-ranging and complex discussions,
2. clarifying hypothesized relationships, as well as screening of policy and management interventions to eliminate options that are unlikely to do much good, and
3. helping to identify key knowledge gaps, suggesting new research projects and illuminating inadequacies in models and interventions.

Acquiring new information and rapidly incorporating new knowledge and experiences into planning and actions are of the utmost importance with NNIPS management due to the number of new species arriving on the scene, the rapid spread of some species, evolving perspectives and laws, and the current lack of proven strategies. Instilling adaptive management cycles into an integrated approach can turn reactive management of invasive plants into a proactive mode (Foxcroft 2004). For adaptation to work, knowledge networks must play the vital role of providing instant information and connectivity (Jordan et al. 2003). Table 8.1 lists the crucial elements of a knowledge network system for NNIPS management, where both real-time information and connectivity are subsystems. While there are many current websites that, when linked together, could provide knowledge networks hosting formidable information resources (see Miller and Schelhas 2008), as yet, these websites have little to no integration or connectivity. However, the linking process is beginning through several national list-servers in the US that provide unstructured connectivity (e.g., regional exotic pest plant councils, Alien Plant Alliance, and Native Plant Conservation).

8.3.2 Collaborative Management

Collaborative management seeks to develop working linkages among all partners that collectively manage land and water resources across ownerships and jurisdictional boundaries within a defined area. One aspect of collaboration involves structures to

Table 8.1 Web accessible knowledge network for invasive plant management must contain real-time information and real-time connectivity to facilitate adaptive management

(A) Real-time information
Invasive species by
Categories of threat
Commodity group and
Land & water-use categories
Detailed identification guides
Occupation maps at expanding scales and spread predictions
Cost-benefit/risk analyses
Control, containment, and eradication methods and restoration procedures
Spread pathways and prevention means
Comprehensive and multi-species strategies
Ecosystem services impacts and safeguards
(B) Real-time connectivity
Decision networks and listserves among collaborative partners (see list in Table 3)
Formal early detection and rapid response network
Directories of service providers for control and restoration
Directories of native plants sources for restoration using local ecotypes
Library of pertinent laws, policies, and strategic plans
Current approved documents such as environmental assessments and environment impact statements

integrate the efforts of different professional agencies and organizations involved in natural resource management. But collaboration often goes farther than this, to include citizen involvement. Natural resource management is no longer the exclusive domain of bureaucrats and scientists. Participatory and community based natural resource management are important trends in the US (Donoghue and Sturtevant 2008; Wilmsen et al. 2008). Moote (2008) notes that collaborative management has a number of different strands, rooted in ideas as diverse as participatory governance, alternative dispute resolution, adaptive ecosystem management, and international community forestry, which leads to four distinct potential areas of benefit:

1. By bringing together stakeholders with multiple, diverse interests to share their knowledge and values related to resource management, both stakeholders and managers can be better informed and new broader understandings can be developed.
2. Conflicts over natural resource management can be reduced if disputing parties can craft innovative new management options that are widely acceptable.
3. Land management agencies can become more responsive to varied social concerns and changing conditions, resulting in greater innovation in management.
4. Local residents, resource users, and landowners can be empowered to bring their knowledge, skills, and energies to shared natural resource management.

Collaboration for NNIPS thus has two components. Horizontal connectivity among landowners and managers links people across landscapes, while vertical networks link local, county, state, regional, and national levels (Colfer 2005). Box 1 summarizes the horizontal and vertical collaboration elements used by the Center for International Forestry Research (CIFOR) in their adaptive collaborative management project that took place at 30 sites in 11 countries across Asia, Africa, and Latin America in the late 1990s. Table 8.2 displays an example from the US, showing the multitude of partners that should be linked within a state at various scales to act in some manner of coordination to enact strategies. Because of federal and state appropriations, most organizational and program formation occurs at the state level, while the actual work happens on the ground (landownership) level. At least 36 states have established some type of interagency invasive species council or working groups to address either selected NNIPS or a range of invasive species (Environmental Law Institute 2002). These councils are either nonprofit organizations, governmental entities, or loose associations of coordinating bodies. The most widely recognized and successful collaborations for invasive plant management in the US have been Cooperative Weed Management Areas (CWMAs), which are organized at the county, multicounty, or state level (Midwest Invasive Plant Network 2006). A CWMA is a partnership of federal, state, and local government agencies; tribes, individuals, and various interested groups that manage noxious weeds or invasive plants in a defined area (Midwest Invasive Plant Network 2006). Most CWMAs were originally formed in the western US and now are being organized in the midwestern, northeastern, and southeastern states. While CWMAs are clearly collaborative networks, it appears that formalized elements of adaptive management have generally not yet been adopted.

Box 1 Horizontal and Vertical Collaboration in Center for International Forestry Research (CIFOR) Projects (Colfer 2005)

Horizontal collaboration. Landscape-level management involves groups of people spread across the landscape who may not regularly be in contact with each other. This can include spatially dispersed individuals and communities, as well as different interest groups such as communities, timber companies, and land managers. Many of these individuals and groups do not naturally form productive working relationships, and efforts must be made to promote linkages and collaboration. CIFOR used three approaches to strengthen horizontal collaboration. *Workshops* serve as the starting point, and can be used to bring representatives from different places and organizations together in structured ways that minimized power imbalance to facilitate free exchange of views. *User groups*—existing or new—provide mechanisms for local interaction, governance, proposal writing, and funding. *Networks*, which have both horizontal and vertical implications, enhance communication among formal groups and stakeholders, and between the public and professional managers and scientists.

(continued)

Box 1 (continued)

Vertical collaboration. The need for understanding and action to work at and across different scales creates the need to structure relationships between people operating at the community level with those operating at higher institutional levels such as state and federal agencies and policy-makers. CIFOR used national level steering committees with 5–7 members from government, academia, nonprofits, and projects to provide guidance on national and regional level priorities and disseminate results. In addition, specific links between levels were developed, often through workshops facilitated with open exchange among levels in mind.

Table 8.2 Potential state collaborative partners for an invasive plant Adaptive Collaborative Research (ACR) program

State level
Department of agriculture and industries
Department of conservation and natural resources
Department of transportation
Forestry commission, department, or service
Land grant universities and extension service
Resource conservation and development districts
Electric power generation and transmission authority
Department of environmental management or protection
Port authority, where appropriate
County and city level
Governing commissions
Planning boards
Roads departments
Parks, formal gardens, and lands
Water providing authorities
Electric cooperatives
Land trusts, realtors, and developers
Citizen groups for natural resource conservation
Federal and state-level agencies
US Natural Resources Conservation Service
US Farm Services Administration
US Fish and Wildlife Service
US Forest Service
US National Park Service
US Bureau of Indian Affairs
River authorities e.g. Tennessee Valley Authority
US Army Corp of Engineers
US Bureau of Land Management
US Geological Survey

(continued)

Table 8.2 (continued)

Industry level
Commodity producers (livestock, crops, turf, fruit and nuts, aquaculture, etc.)
Timber producers
Plant production, wholesale, and retail industry (terrestrial and aquatic)
Gas and other pipeline companies that manage right-of-ways
Invasive control consultants
Restoration consultants
Herbicide and equipment producers, distributors, and retailers
Mining
Energy development
Non-governmental partners
The Nature Conservancy and land trusts
Invasive plant councils
Farmer, forestry, and cattle producer associations
Wildlife, hunting, and fishing associations and federations
Native American tribal councils

8.3.3 Restoration Management

Restoration management is an indispensable part of integrated invasive plant management that provides the necessary concepts and methods for maintaining or creating native or non-invasive plant communities (Sauer 1998; Miller 2003). An overarching objective of restoration management is to increase both resistance to invasion and resilience, and the ability to recover, following disturbance. An effective restoration program begins with preventative management specifically designed to maintain or increase ecosystem resistance prior to or during the early stages of invasion and establish environmental and biological components that promote ecosystem resilience after a disturbance (Masters and Sheley 2001). This often can be accomplished by manipulating or maintaining structural properties and ecosystem processes known to favor the persistence or recovery of resident or desirable species (D'Antonio and Chambers 2006). It may involve passive approaches, such as removing a stressor like overgrazing by livestock, or active approaches, such as reinstating disturbances like a more natural flood regime or fire return interval (DellaSala et al. 2003). Following invasion, active restoration or rehabilitation often is required and typically begins with control or suppression of the NNIPS. In many cases it is necessary to first eliminate or reduce propagules of competitive NNIPS species in order to establish native or desirable species. Natural succession can play an important role when NNIPS methods are used that safeguard native species and the soils seed bank (Barnes 2004; Allen et al. 2007). In those cases where native propagules are severely depleted or are incapable of competing with NNIPS, revegetation with more competitive native cultivars or other desirable species may be required in addition to NNIPS control (Ewel and Putz 2004). In highly disturbed ecosystems, rehabilitation/reclamation can involve stabilizing the soil surface, modifying the soil characteristics, and adding plants in the form of seeds or transplants (Whisenant 1999). When native plants are incapable of persisting under the new environmental regime, it may be necessary to create communities of adapted cultivars that can exist under the new conditions. Soil changes caused by invasive occupation may even require amelioration with fertilization and liming (Ehrenfeld et al. 2001).

8.4 Invasive Plants in the Forests and Grasslands of the Southeast

NNIPS are a monumental problem in the forests and grasslands of the Southeast (Miller 2003; Britton et al. 2004), a region characterized by tens of millions of private landowners and very little public lands. The 216 million hectares (534 million acres) of forest in the southeastern US represent one of the most productive forest regions in the world. These forests supply 62% of US timber as well as a variety of ecological services (Wear and Greis 2002; Prestemon and Abt 2002).The private ownership presents extreme challenges for Adaptive Collaborative Restoration (ACR) procedures. In the 13 southeastern states that comprise the region, 33 taxa of NNIPS occupy an estimated 9% of interior forests, forest edges, and small openings—about seven million hectares (18 million acres). This estimate comes from the US Forest Service's region-wide survey from 2001 to 2008, performed in 12 states in cooperation with state forestry agencies (Miller et al. 2008). The most pervasive invaders are listed in Table 8.3 and some are shown in Fig. 8.1. In spite of their invasive status, all but Japanese stiltgrass are still propagated, grown, and sold by the plant industry and planted by landowners. Others are widely used by the public sector. For example, tall fescue is a commonly used pasture and stabilization grass that spreads along right-of-ways to invade forest edges, opening, and special habitats like high elevation glades and balds. Maps of occupation and tabular coverage estimates for the 33 severe NNIP are web accessible (Miller et al. 2008). These maps and data are made provided as tools to focus state, county, agency, and individual's invasive plant management programs and to gain greater support.

A recent compilation by the US Forest Service Southern Region Task Force on Invasive Species identified 388 NNIPS that occur as free living populations in

Table 8.3 Most pervasive invasive plant species in the Southeastern US

Plant	Hectares occupied
Japanese honeysuckle (*Lonicera japonica*)	4.1 million
non-native privets (*Ligustrum* spp.)	1.3 million
Tall fescue (*Schedonorus phoenix)*	429,000
Japanese stiltgrass (*Microstegium vimineum*)	262,000
non-native roses (*Rosa* spp.)	241,000
Chinese tallowtree (*Triadica sebifera*)	185,000

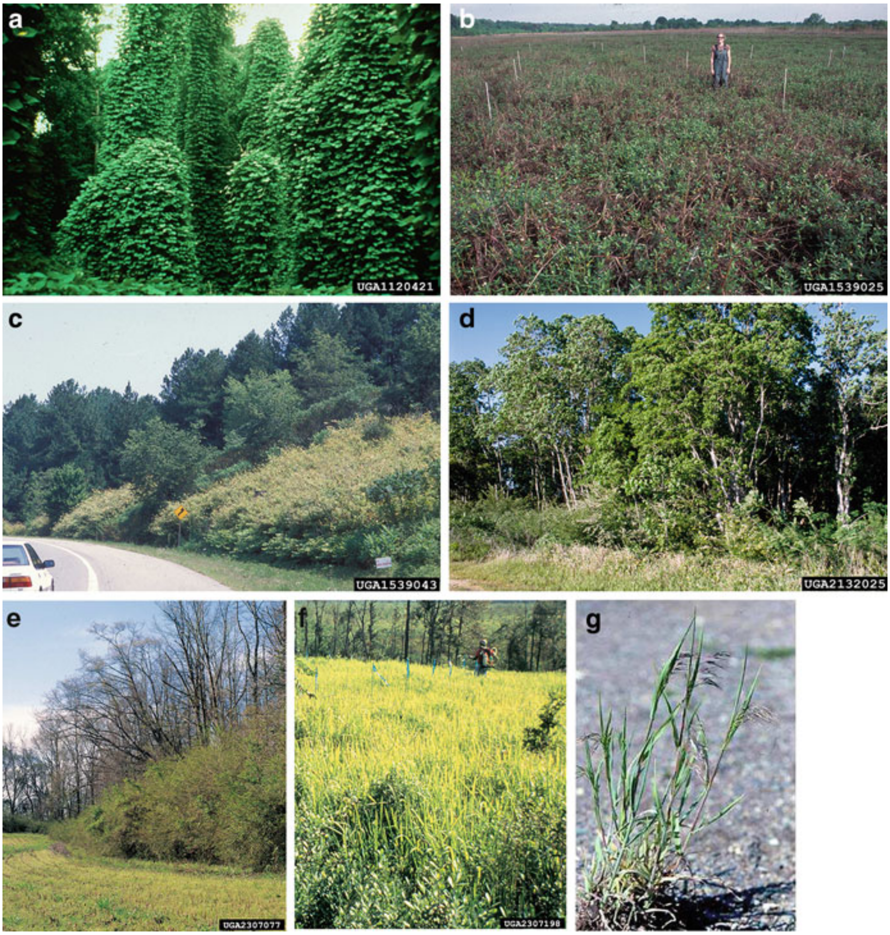

Fig. 8.1 The most pervasive invaders in the US. (**a**) Kudzu (*Pueraria montana*) infestation. (**b**) Alligatorweed (*Alternanthera philoxeroides*) infestation in wetlands. (c) Japanese knotweed (*Polygonum cuspidatum*) infestation along highway. (**d**) An invasive forest community composed of Tallowtree (*Triadica sebifera*), silktree (*Albizia julibrissin*), Chinese privet (*Ligustrum sinenese*), cogongrass (*Imperata cylindrica*), and Japanese honeysuckle (*Lonicera japonica*). (**e**) Chinese privet (*Ligustrum sinenese*) under native hardwoods preventing forest regeneration. (**f**) Cogongrass (*Imperata cylindrica*) infestation with research plots undergoing herbicide testing. (**g**) Cheatgrass (*Bromus tectorum*)

southeastern forests, native grasslands, and their waters (USDA Forest Service Southern Region 2008). These new insights on the scope and amount of occupation and the growing number of invaders gives cause for rapid formulation and enactment of collaborative networks using collective knowledge in adaptive management cycles to prevent further invasion and restore degraded ecosystems. Much effort has been underway and the highlights and chronology of developments are worthy of documentation as they relate to ACR principles.

NNIPS collaboration networks in the southeast are presently aimed at horizontal connectivity, usually state centered. The leading collective efforts focused on managing NNIPS are Exotic Pest Plant Councils (EPPCs) linked through the internet, university centers, vegetation management associations, and fledging Cooperative Weed Management Areas (CWMAs). The first EPPC formed in the US was the Florida Exotic Pest Plant Council (FL-EPPC), established in 1984 to bring together numerous agencies combating severe NNIPS invasions in South Florida natural areas. Formation was stimulated by the common plant foes encountered in the Everglades ecosystem and tropical south Florida, along with uniquely high levels of state and federal funding. The strong FL-EPPC leadership and dedicated membership developed the first mission statements, bylaws, state invasive list, and identification and control publications that followed. Membership has been open to everyone and the focus remains solely on natural areas.

Using the same template, the Tennessee Exotic Pest Plant Council (1996) (TN-EPPC) was established in 1994 with the assistance of FL-EPPC and support by the Great Smoky Mountains National Park, which has had an invasive plant control program underway since the 1970s, one of the earliest in the region. A regionally valuable Tennessee Exotic Management Manual was soon produced by an expert team (Tennessee Exotic Pest Plant 1996), which has undergone frequent revisions. TN-EPPC also took the lead in organizing the Southeast EPPC to fulfill an overarching regional mission and was instrumental in the formation of the National EPPC (NA-EPPC) in 1997. Between 1999 and 2005, EPPCs were organized in Georgia (1999), Kentucky (2000), Alabama (2002), Mississippi (2002), South Carolina (2003), North Carolina (2005), and Texas (2009). Most of these EPPC's broadened their scope from a focus only on natural areas to include partners representing all components of the intricate modern landscape including right-of-way managers, gardeners, and native plant enthusiasts. State and regional annual symposia share current developments in research, policy, new NNIPS arrivals, and council activities that have helped to propel invasive management efforts in the region. All state EPPCs are a focus for expert and volunteers to participate on their boards and committees that promote policy changes on sales and transport of NNIPS within states, compile lists of NNIPS according to risk categories, fund control projects, and convene annual conferences to share the latest research results and progress. These embody and enact collaborative and adaptive management roles.

Collaboration and adaptation is also furthered by SE-EPPC and state EPPC websites being hosted at the Center for Invasive Species and Ecosystem Health (CISEH) at the University of Georgia, which was officially recognized by the university in 2008 although in operation since 1994. The CISEH has created and hosts many major websites on invasive species and forest management, which have regional, national, and international dimensions (Table 8.4). The CISEH, in cooperation with the US Forest Service and other agencies, formulates and provides critical information such as: the NNIPS listed by the 13 southeastern states, identification and control guides for most NNIPS, details on the severe NNIPS like cogongrass (*Imperata cylindrica*), and posts proceedings of state and SE-EPPC symposia. Regional connectivity for individuals and agencies on NNIPS matters is also being provided by

Table 8.4 Websites hosted and maintained by The University of Georgia's Center for Invasive Species Science and Ecosystem Health (CCISEH)

Web sites
Database system websites
Invasive.org, www.Invasive.org
Forestry images, www.ForestryImages.org
IPM images, www.IPMImages.org
Insect images, www.InsectImages.org
Bugwood images, images.bugwood.org
Other center websites
Bugwood, www.bugwood.org
Bugwood Wiki, wiki.bugwood.org
Early detection and distribution mapping system, www.eddmaps.org
Widely prevalent fungi, www.prevalentfungi.org
Forest*A*Syst: forest landowner's assessment guide, www.forestasyst.org
Forest pests of North America, www.forestpests.org
Bark and wood boring beetles of the world, www.barkbeetles.org
Georgia integrated pest management, www.gaipm.org
Cogongrass in the Southeast US, www.cogongrass.org
Eastern Arc mountains of Tanzania and Kenya, www.easternarc.org
Hosted websites
Georgia Exotic Pest Plant Council, www.gaeppc.org
Georgia Invasive Species Task Force, www.gainvasives.org
Southeast Exotic Pest Plant Council, www.se-eppc.org
Florida Exotic Pest Plant Council, www.fleppc.org
National Association of EPPCs, www.naeppc.org
Southern Forest Insect Work Conference, www.sfiwc.org
Everglades Cooperative Invasive Species Management Area, www.evergladescisma.org
Florida Invasive Species Partnership, www.floridainvasives.org
River to River Cooperative Weed Management Area, www.rtrcwma.org
Northern Rockies Invasive Plant Council, www.nripc.org
National Network of Invasive Plant Centers, www.invasiveplantcenters.org
Silvopasture: establishment and management principles for pine forests in the Southeastern United States, www.silvopasture.org
Regional Tropical Soda Apple Task Force, www.tropicalsodaapple.org

the CISEH through their hosting of a SE-EPPC membership list-server and blog dedicated to NNIPS. CISEH maintains an image database system containing over 90,000 high resolution images of native and non-native species (Bargeron et al. 2006), which are widely used for education.

A reporting and mapping website for eight states with EPPCs is also hosted by the CISEH, EDDMapS—Early Detection and Distribution Mapping System (Bargeron and Moorhead 2007). Voluntary inputs of those species on state EPPC lists are possible and each state has a designated verifier to review submitted photographs or voucher specimens used for documentation. Maps are publicly accessible. EDDMapS will be expanded to include the Mid-Atlantic states and Alaska in 2009. It also includes all US county records for 1200 invasive plants from the WeedUS database (www.invasive.org/weedus/). A cooperating parallel mapping project, the Invasive Plant Atlas of the MidSouth, is under construction at Mississippi State University's GeoSpatial Institute. Another voluntary mapping database was created in 2008 at the Woodrow Wilson School at Princeton University, The Invasive Species Mapping Program, and focuses on mapping the Southeast distribution of Chinese privet (*Ligustrum sinense*), kudzu (*Pueraria montana* var. *lobata*), and cogongrass (Marvin et al. 2008). These databases are being linked and projected to map most NNIPS in the region. The linked databases are projected to eventually provide an effective and efficient Early Detection and Rapid Response (EDRR) network to identify and locate new high risk introductions, communicate and verify the sites, eradicate the outlier infestations, and restore plant communities resistant to re-invasion (Westbrooks 2004).

A solidifying movement of multi-state collaboration came with the recognition of cogongrass as one of the region's major NNIPS threats. A regional conference was convened, and resulted in the compilation of the 15 expert presentations into *The Cogongrass Management Guide*, which includes a regional management strategy with zones of invasion shown on a regional map and specific objectives, survey approaches, and treatments for each zone (Loewenstein and Miller 2007). The University of Georgia's Center hosts the www.cogongrass.org website where the proceedings, all presentations, and state management guides for this species are posted and appended. With the assistance of a US Forest Service grant, cogongrass task forces were formed in Alabama, Georgia, South Carolina, and north Florida, to join the existing one in Mississippi. The collaborative members of the task forces (many from those in Table 8.3) have entered into memoranda of understanding for cooperative action within the constraints of existing budgets and constructed strategic plans to guide ACR within states. These documents have been used to gain over $12 million for cogongrass and other NNIPS species over multiple years. This was the first granting of significant funds to combat invasive plants in the region. It is a pattern that apparently will continue.

The collaborative structures of Cooperative Weed Management Areas that started in the US West in the 1980s and more recently organized in the US Midwest have been slower to form in the Southeast. This is partially due to the absence of extensive federally managed lands that aided the West to organize and led to modification for multi-stakeholders in the Midwest (Bebber 2006). The majority in the Southeast are the 12 single or multiple county CWMAs in Florida that come from the longer history of NNIPS organizations in the state. The first CWMA in the region outside of Florida was in north Alabama established in 2006. In 2008, two notable state-wide CWMAs were formed in Mississippi and Georgia that will address an array of NNIPS. More discussions are underway towards forming CWMAs based on the protocols of the Midwest Invasive Plant Network (Bebber 2006) that has hosted teleconferences with interested individuals in the southeast in 2007.

An exemplary program of ACR is the Upland Invasive Exotic Plant Management Program in Florida. The program was developed and implemented in 1997 by the Florida State Bureau of Invasive Plant Management with the assistance of over 520 local, state, and federal public conservation land managers, non-government organization representatives, and private citizens. These co-operators are organized into 11 regional working groups that provide direction for the annual state funding of upland weed control projects. The program incorporates the concept of placed-based management, which allows for regionally diverse interests and concerns to implement flexible, innovative strategies, while maintaining state-wide consistency and accountability. To date, the program has expended approximately $60 million of state funding, matched with over $25 million in cooperator cost-share, to achieve initial control of nearly 200,000 ha of weeds (involving over 100 weed species) on 400 public conservation areas. These efforts were accomplished through over 1,000 individual projects in cooperation with 5 federal, 11 state and regional, and 41 local government entities. Again, the power of appropriated funds, even without year-to-year consistency, are evidently the needed ingredient in sustaining ACR Programs.

Restoration treatments to dove-tail with control and eradication efforts in the region have yet to be developed in the southeast and represent a principal research and development challenge. While many state and federal agencies have cost-share and incentive programs for NNIPS control by landowners, only the planting of longleaf pine (*Pinus palustris*) by the US Fish and Wildlife Service and more recently the National Resource Conservation Service addresses restoration following treatments. Most of the large invasive plant management companies have performed control and restoration projects for municipalities, like Chattanooga, and military reservations, but this knowledge has not been shared or disseminated. Awareness is growing, especially when treating cogongrass, that restoration or rehabilitation will be a necessary treatment component to ensure invasive plant suppression and assured ecosystem functions and services are maintained.

Experience from the southeastern US shows that collaborative efforts do not come together all at one time. Initial efforts have been limited in geographic scope and generally focused on individual species of particular concern. Yet, over time, these efforts are increasingly linked together, providing knowledge platforms that are both important and responsive. Websites mapping invasives, assisting in identification, and providing protocols for treatments play an important role in stimulating action. Ultimately, we are seeing a hierarchy of organizations developed that promote action and allow coordination at the local, state, regional, and national levels. At the same time, links are being developed across states, often with federal agencies and state universities playing coordinating roles.

8.5 Invasive Plants in the Great Basin

In the Great Basin of the western US, non-native invasive annual grasses like cheatgrass (*Bromus tectorum*) are rapidly spreading throughout the region (Mack 1986; Knapp 1996). The initiation of an annual grass/fire cycle has altered fire regimes and is resulting in large scale conversion of native salt desert shrub, sagebrush steppe, and lower elevation pinyon-juniper woodlands to homogenous landscapes dominated by the non-native annual grasses (D'Antonio and Vitousek 1992), Fig. 8.2. These large-scale

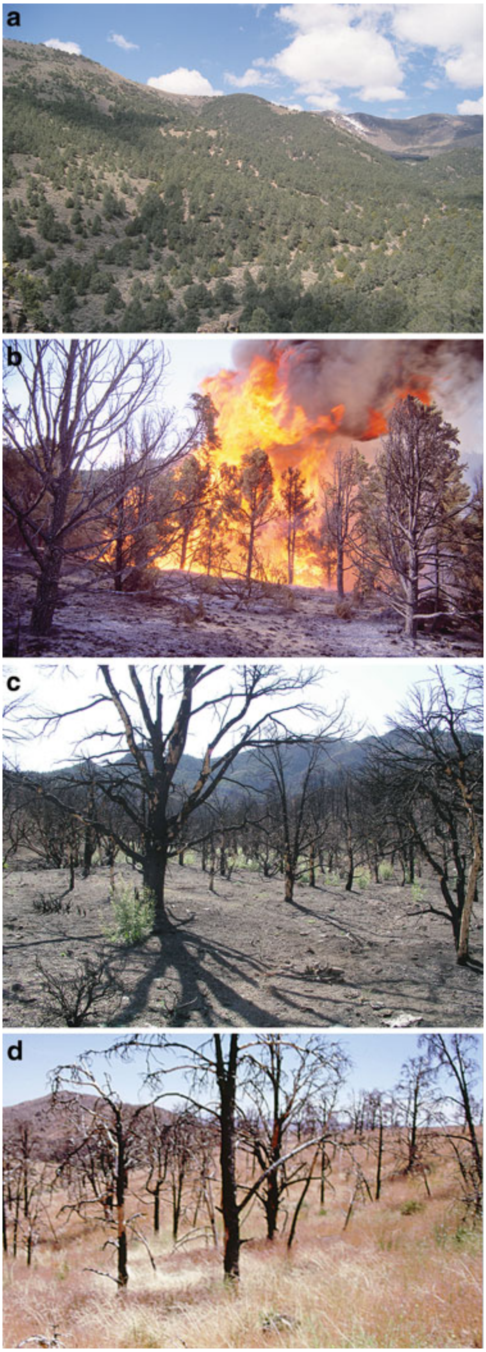

Fig. 8.2 Altered fire regimes have converted native salt desert shrub, sagebrush steppe, and lower elevation pinyon-juniper woodlands to homogenous landscapes dominated by the non-native annual grasses: (**a**) A sagebrush (*Artemisia tridentata*) ecosystem exhibiting expansion of single-needle pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osterosperma*). Growth and infilling of the native tree species results in progressive decreases in sagebrush understory species and increases in fuel loads. (**b**) A high severity fire in a single-needle pinyon and Utah juniper dominated site. (**c**) A single-needle pinyon and Utah juniper dominated site after a high severity wildfire that has killed the trees. The ecological resilience or recovery potential of the site is low because few residual perennial herbaceous species remain and the seedbanks of these sites are often low. There is a high risk of invasion by the non-native annual grass, cheatgrass (*Bromus tectorum*), and other weedy annual invaders. (**d**). A site that was dominated by single-needle pinyon and Utah juniper prior to a high severity wildfire that has crossed an ecological threshold and that has been converted to cheatgrass dominance

changes are altering ecosystems processes (Chambers et al. 2007) and placing native plant communities and their associated animal species at risk (Wisdom et al. 2005). More recently perennial forbs have begun to invade the semi-arid region with poorly understood effects on both fire regimes and ecosystems. The rate and magnitude of the changes occurring lend a sense of urgency to developing effective ACR for the region (Chambers et al. 2008). In the Great Basin 72% of the land is federally owned and federal land management agencies play a significant role in these activities.

Several different collaborative efforts have coalesced around the need to restore and maintain sustainable ecosystems in the Great Basin. These efforts include federal, state and local led programs as well as programs that target critical needs. The Great Basin Restoration Initiative (GBRI) was initiated by the Bureau of Land Management (BLM) in 1999 after nearly 0.7 million ha of the Great Basin burned in wildfires—one of the largest fire years on record (Pellant et al. 2005; USDI Bureau of Land Management Great Basin Restoration Initiative 2008). The objective of GBRI is to restore plant community diversity and structure by improving resiliency to disturbance and resistance to invasive species over the long-term (Pellant et al. 2005). A strategic plan has been developed to accomplish this objective that emphasizes local participation and reliance on science to ensure that restoration is accomplished in an economical and ecologically sound manner. Guiding principles include: (1) applying a landscape-scale approach, (2) emphasizing the conservation (protection) of healthy, functioning native plant communities before restoring degrading lands, (3) pooling financial resources, and (4) promoting a science-based approach.

The Eastern Nevada Landscape Restoration Project is a place-based effort that utilizes the same principles as the Great Basin Restoration Initiative (Eastern Nevada Landscape Coalition 2008). It is a collaborative effort among the local field offices of the Bureau of Land Management, other federal and state agencies working in the area, and the Eastern Nevada Landscape Coalition (ENLC)—a community-based partnership of 100-plus members representing a broad spectrum of public land users and non-governmental organizations. The objective of the ENLC is to facilitate the restoration or maintenance of more than 4-million ha of public lands in eastern Nevada. A Resource Management Plan and Environmental Impact Statement has been completed that will provide management direction in the planning area for the next 20-plus years, as well as fulfill obligations set forth by the National Environmental Policy Act. On-the-ground projects aimed at managing species invasions and fire frequency and size are ongoing.

The Utah Partners for Conservation and Development (2008)(UPCD) is a state-based effort led by the Utah Department of Natural Resources that has a slightly different emphasis. It serves as a clearinghouse for coordinating and sharing participants' conservation concerns and priorities, discussing potential solutions and fostering an atmosphere where collaboration becomes the rule rather than the exception for implementing conservation activities (Utah Partners for Conservation Development 2008). It consists of the major state and federal agencies involved in restoration activities in Utah. The primary objective of the UPCD is to restore and manage ecosystem health in priority areas throughout the State of Utah through active restoration, administrative changes in land management such as livestock grazing plans, fire plans, recreation/travel plans and wildlife plans, and communication and team building with the public, stakeholders and the conservation and development partners. Like the ENLC, the UPCD has a strong focus on project implementation.

Effective restoration and management of Great Basin ecosystems requires collaborative efforts to address specific science and management needs. These efforts are focused in several different areas such as providing regional assessments and databases, building restoration capacity, and finding the answers to critical research and management questions related to non-native invasive plant species and restoration of Great Basin ecosystems. The USGS Great Basin Integrated Landscape Monitoring (GBILM) Pilot Project (2008) is addressing ecological monitoring at the landscape scale by developing and testing state-of-the-art landscape monitoring approaches. It is a collaborative project among the USGS, Boise State University, the Western Association of Fish and Wildlife agencies, Bureau of Land Management, US Fish and Wildlife Service, and National Park Service. Landscape-scale information is acquired on water extraction, fire regimes, invasive species, land treatments, land-cover change, and climate variability to aid land managers in cumulative effects assessments, relating local actions to the landscape-scale context, and prioritizing areas for treatment. This information is then used to: (1) assess cumulative effects of local actions/events; (2) evaluate change at the landscape scale; (3) develop the capacity to predictive landscape change; (4) develop or refine monitoring strategies; and (5) prioritize actions for mitigation, conservation or restoration.

The Great Basin Native Plant Selection and Increase Project is a multi-state, collaborative research project that was initiated in 2001 by the US Bureau of Land Management, Great Basin Restoration Initiative, and the US Forest Service, Rocky Mountain Research Station, Grassland, Shrubland and Desert Ecosystem Research Program (Great Basin Native Plant Selection and Increase Project 2007). More than 20 federal, state, and private cooperators, including all of the region's universities, are involved in this project. The overall goals are to improve availability of native plant materials and to provide knowledge and technology required for their use in restoring diverse native plant communities across the Great Basin. Specific objectives include examining interactions of native restoration species and non-native invasive plants to assist in developing seeding mixtures and methods. They also include collaborating with seed regulatory agencies and the private seed industry to improve native seed supplies.

SageSTEP (Sagebrush Steppe Treatment Evaluation Project 2007) is a regional research and management experiment to evaluate methods of sagebrush steppe restoration in the Great Basin. It is a collaborative, multi-disciplinary project among the major land management agencies in the region, BLM and Forest Service, primary federal research agencies (Forest Service Rocky Mountain Research Station, Geological Survey, and Agricultural Research Service), and region's universities. The Sage STEP project seeks to identify conditions that determine the transition between sustainable and non-sustainable sagebrush plant communities as related to threats posed by cheatgrass invasion and woodland encroachment.

Fig. 8.3 The research team for the SageSTEP (Sagebrush Steppe Treatment Evaluation Project) at a field workshop to determine the types of data required by the different research disciplines and to develop consistent methodologies for the 13 sites in the study network

It is evaluating the effects of land management treatments (fire, mechanical thinning, and herbicide) over gradients of cheatgrass invasion or woodland encroachment in order to define the recovery thresholds of native sagebrush ecosystems. A multi-disciplinary approach is used in which effects on soils, plant communities, and wildlife are evaluated as well as the potential for future wildfires as indicated by fuel loads, Fig. 8.3. Society's responses to and the economic effects of invasives, wildfire and management treatments aimed at controlling them are assessed for sagebrush ecosystems. Project results are used to develop recommendations and guidelines for management strategies and methods to maintain and restore sagebrush ecosystems before recovery thresholds are crossed.

Information sharing and education is critical for developing successful restoration and land management strategies and for obtaining the necessary public support for management activities. The USGS National Biological Information Infrastructure (NBII), Great Basin Information Project (GBIP) links data and information maintained by federal, state, and local government agencies; non-government organizations; and private-sector organizations through a single website. The GBIP partners include the numerous state and federal agencies. The GBIP provides consolidated information that is readily accessible to a variety of audiences including researchers, natural resource managers, decision-makers, educators, students, and other private citizens (USGS National Biological Information Infrastructure, Great Basin Information Project 2008). Efficient access to scientific and educational information allows stakeholders to explore the biological diversity in the region and work together in an informed fashion. Its web-based products include: (1) a 3,500 record searchable bibliography; (2) an Educational Internet Mapper that provides viewing, manipulation,

Fig. 8.4 Research and management partners at a regional workshop on "Collaborative Research and Management in the Great Basin" designed to review critical management needs, increase awareness of the activities of research and management organizations, and develop a collaborative approach for improving coordination and communication

and printing of maps showing important natural and cultural features in the region, (3) the Science Locator which is a collaboration tool designed to allow researchers and managers one-click access to information about ongoing science and management projects in the region; (4) an Image Locator with several thousand readily accessible photographs of Great Basin animals, plants, and landscapes; and (5) a Metadata Server that includes information about spatial and biological data that overlay the extent of the Great Basin, and allow data users to search, retrieve, and evaluate data sets by providing standardized descriptions of geospatial and biological data.

Collaboration among research and management organizations in the Great Basin can be significantly enhanced by effective communication and information sharing. The Great Basin Research and Management Partnership (GBRMP) provides an integrated organizational framework to promote comprehensive and complementary collaborations, and to provide leadership, commitment and guidance to ensure that the collaborations are effective. It is comprised currently of representatives of the major federal and state organizations working within the region. The vision of GBRMP is multi-disciplinary, multi-organizational teams that include federal, state, local, tribal, private and NGO partners working together to develop solutions to the region's ecological and socio-economic issues using existing management and research frameworks. It aims to obtain consensus on priority issues, cross organizational and administrative boundaries in order to address larger spatial and temporal scales, address the need for science-based information to guide management decisions and actions, and improve communication and information sharing among all of the stakeholders within the Great Basin, Fig. 8.4.

In a region as large and diverse as the Great Basin, collaborative approaches to restoration and management are essential for addressing issues associated with non-native invasive plants.

8.6 The Challenge of Adaptive Collaborative Restoration

The ideal of ACR—that people can collaborate across institutional and property boundaries and across local to national levels to carry out complex processes of invasive species detection, prevention, and eradication and restore ecosystems in reflective scientific-based, adaptive learning processes—is in many ways a tall order. Yet it is not clear what would be alternative approaches to achieve the critical objectives. While there are few fully functioning adaptive collaborative management or restoration processes to serve as real world models, there are many ongoing efforts such as the efforts described above in two regions of the US as well as in other parts of the world (Buck et al. 2001; Colfer 2005). Natural resource managers worldwide, facing similar management issues, are either adopting adaptive collaborative ideas as a formal approach or drawing on its general principles to improve existing management approaches. Clearly, the ideas of ACR are of great relevance to the common difficulties being faced by invasive plant management. New scientific understanding is rapidly accumulating on particular species impacts and means of control, while formal publication of results in scientific journals is too slow and too restrictive. Translating this information into useful technology that is then communicated through collaborative knowledge networks and finally put to use on the ground is critical. It is also important to note that most ongoing efforts, including the two documented in this paper, emphasize only some elements of ACR and these are often tilted toward either science-based adaptive management or collaborative governance approaches (Schelhas et al. 2001). Yet an awareness of the full vision of ACR can be helpful in guiding these efforts into the future.

Establishing fully comprehensive ACR processes across logical units of the landscape is indeed a daunting task, and clearly it will take time for public awareness and political will to develop to the point that this can happen. With that in mind, it is important to understand that, because many policy-makers, managers, and scientists are individually grappling with the same problems, many of the components of ACR are already being put into place, like CWMAs, invasive species task forces, and knowledge networks. The principles of ACR and the concepts and elements presented here can assist in crafting roadmaps for the expansion of interlinked knowledge networks. State and county leaders with their constituents and partners can continue to form cooperative networks that will increasingly carry out collaborative actions and gain funds that move things in the right direction. Individual scientists can create knowledge and syntheses that are available on websites with updating cycles in an adaptive manner, like current annual state extension weed control recommendations. Agencies and universities can orchestrate linkages among websites and develop intelligent networks that integrate knowledge and site specifics to guide management and restoration prescriptions. ACR must build on existing institutions, issues, and interests at specific places, and will not look the same everywhere. Furthermore, ACR will always be a work in progress—never fully realized and always adapting to a changing world. Most importantly, though, it is an approach big and flexible enough to meet the growing challenge of restoring NNIPS-compromised ecosystems.

8.7 Management Implications

- Invasive plant control efforts generally begin in narrow geographic areas and often focus on individual species. Over time, as the invasive plants garner more attention, more comprehensive approaches and linkages tend to develop.
- Websites and other information resources that provide maps, identification assistance, and control protocols play an important role in raising awareness and facilitating action.
- True collaborative action efforts develop slowly, but are of critical importance. On the local level, Cooperative Weed Management Areas have been the most viable development; at the state and regional level, a nested series of tasks forces help raise awareness and provide necessary coordination. Government and university support play an important role in establishing and maintaining linkages.
- Science and adaptive management are important in developing methods to control invasive species, and in developing restoration approaches that facilitate long-term control. Control of invasive plants is most effective when accompanied by ecosystem restoration.

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